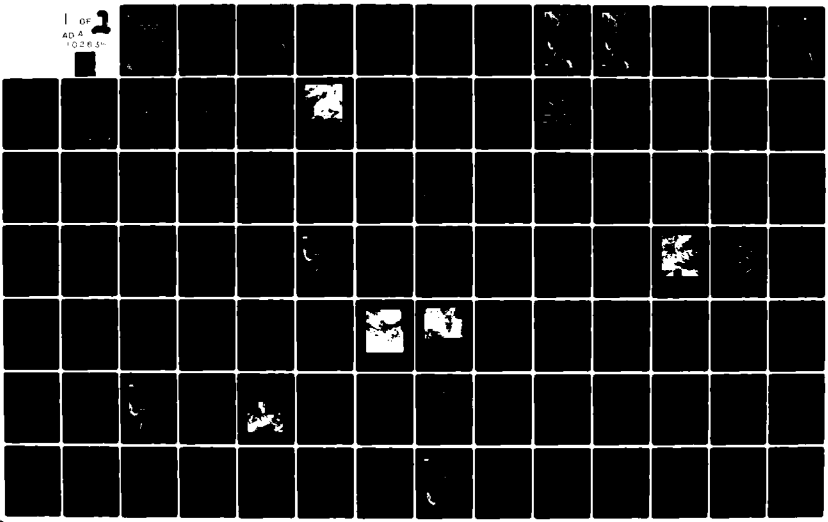
AD-A102 635 NAVAL ENVIRONMENTAL PREDICTION RESEARCH FACILITY MON--ETC F/G 4/2
HANDBOOK FOR FORECASTERS IN THE MEDITERRANEAN. PART 2. REGIONAL--ETC(U)
DEC 80 L R BRODY, M J NESTOR
UNCLASSIFIED NEPRF-TR-80-10-PT-2 NL

1 OF 2
AD A
102635



LEVEL (12)

NAVENVPREDRSCHFAC
TECHNICAL REPORT
TR 80-10

Handbook for Forecasters in the Mediterranean, Part 2

REGIONAL FORECASTING AIDS FOR THE MEDITERRANEAN BASIN

L. R. Brody and LCDR M. J. R. Nestor, RN
Naval Environmental Prediction Research Facility

DECEMBER 1980

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

81 8 10 051

NAVAL ENVIRONMENTAL PREDICTION RESEARCH FACILITY
MONTEREY, CALIFORNIA 93940

UNCLASSIFIED 14 NEPRF-TR-80-10-PT-2

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVENVPREDRSCHFAC Technical Report TR 80-10	2. GOVT ACCESSION NO. AD-A102 635	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Regional Forecasting Aids For The Mediterranean Basin (Handbook for Forecasters in the Mediterranean, Part 2)		5. TYPE OF REPORT & PERIOD COVERED 9 Final Rept.
		6. PERFORMING ORG. REPORT NUMBER TR 80-10
7. AUTHOR(s) 10 L.R. Brody and LCDR M.J.R. Nestor, RN		8. CONTRACT OR GRANT NUMBER(s) 16
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Environmental Prediction Research Facility Monterey, CA 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE 63207N PN 7W0513 TA CC00 NEPRF WU 6.3-11
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Air Systems Command Department of the Navy Washington, DC 20361		12. REPORT DATE 11 December 1980
		13. NUMBER OF PAGES 178 12
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) 6 Handbook for Forecasters in the Mediterranean. Part 2. Regional Forecasting Aids for the Mediterranean Basin.		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

DTIC ELECTE AUG 10 1981 S D C

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Mediterranean region	Mistral	Gregale
Mediterranean climatology	Bora	
Mediterranean forecasting	Etesian	
North African cyclogenesis	Sirocco	
Genoa cyclogenesis	Levante	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Local weather phenomena are described, and localized forecasting rules are given, for each of seven geographical areas of the Mediterranean Basin. As drawn for this study, the areas' boundaries generally define the areas of occurrence of the various weather conditions and events that are found from one location to another across the region. For the operational forecaster's ease of reference, each text section addresses a particular geographical area and provides the following information for that area: an overview of local geography and seasonal

(continued on reverse)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20, Abstract, continued

weather patterns; discussions of weather phenomena common to the area; and a series of forecasting rules cross-referenced to the phenomena discussed. Area locator maps, charts of typical weather conditions and events, satellite images, and rules-index tables are provided to enhance the operational usefulness of the information for the on-site user.

CONTENTS

INTRODUCTION

Purpose. The forecasting rules and discussions of weather phenomena presented in this publication have been compiled from a variety of scientific, analytical, and local-experience sources* to provide localized, working guidance for the operational forecaster in the Mediterranean Basin. In both its content and its organization, the information is intended to be directly applicable and readily referenced in support of local forecasters' analysis/prediction efforts.

Reference. This publication can be used either in conjunction with, or independently of, the first part of the Handbook for Forecasters in the Mediterranean, a monograph subtitled "Weather Phenomena of the Mediterranean Basin, Part 1: General Description of the Meteorological Processes" (ENVPREDRSCHFAC Technical Paper 5-75, November 1975, 344 pp). Present readers should be aware, however, that many of the weather phenomena addressed in Part 2 are described and discussed more fully in Part 1. Thus Technical Paper 5-75 can be a valuable reference work for forecasters and other operational personnel who seek a wider understanding of the region's overall meteorology.

Organization. Because of the variability of weather conditions and events from one location to another across the Mediterranean, the information given herein is divided into seven sections for seven geographical areas numbered sequentially from west to east. The subdivisions' boundaries are drawn, as much as possible, to delineate the areas of occurrence of the various weather phenomena for which forecasting rules and discussions are given. The boundaries also coincide with those of the British-nomenclature "forecast sea areas" still used by some Mediterranean agencies to specify locations of weather events. The seven geographical areas defined for this publication are shown in Figure 1a. The twenty-six British forecast sea areas are shown in Figure 1b.

---

*The following British publication was an important source of local-experience information: Meteorological Office, Air Ministry, 1962: Weather in the Mediterranean, general meteorology, vol. 1. Her Majesty's Stationery Office, London, 372 pp.

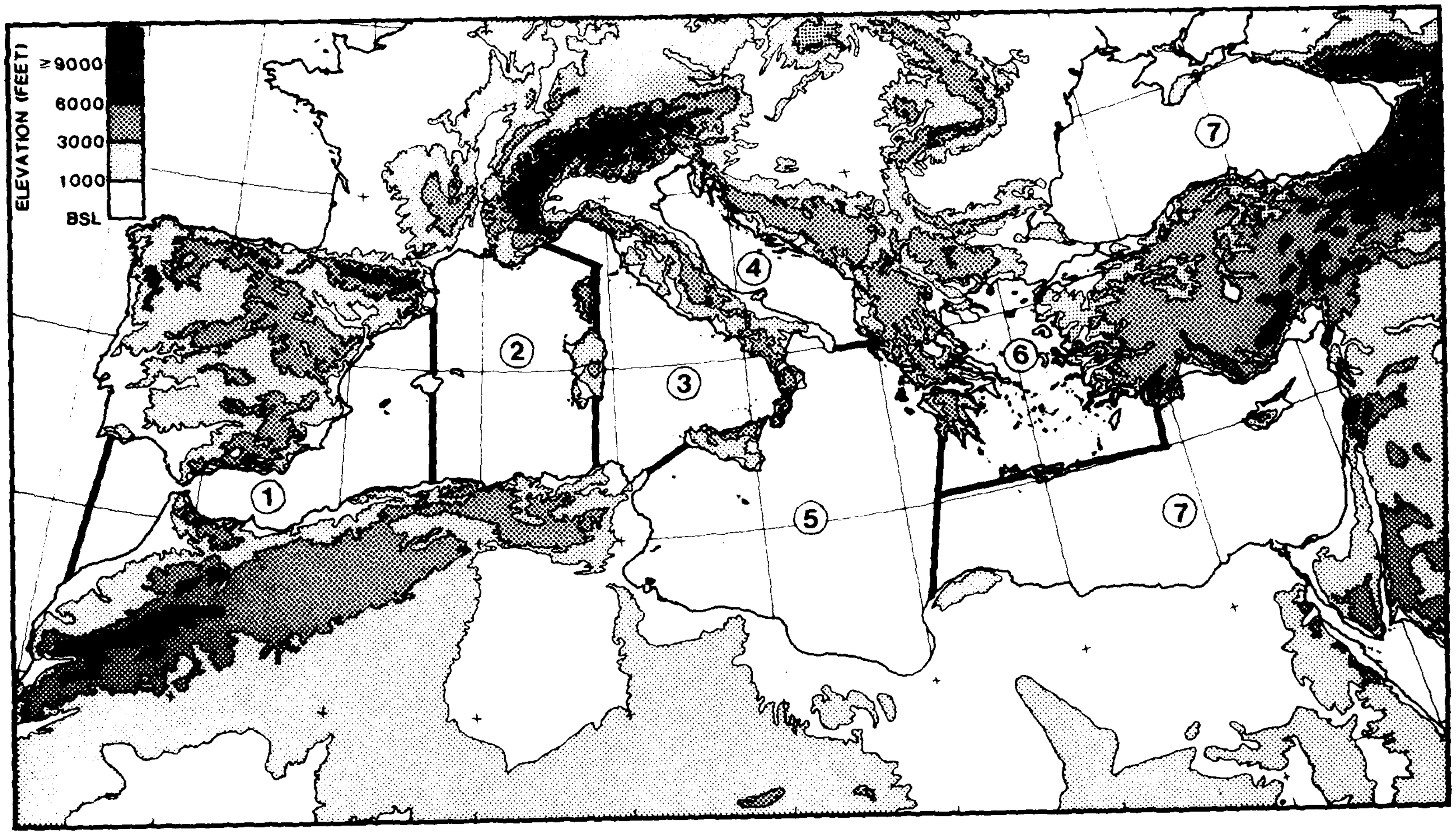


Figure 1a. Areas of the Mediterranean region discussed in Sections I-VII: 1 -- Gibraltar - Western Mediterranean (I); 2 -- Gulf of Lion - West Central Mediterranean (II); 3 -- Tyrrhenian Sea - Central Mediterranean (III); 4 -- Adriatic Sea (IV); 5 -- Ionian Sea - East Central Mediterranean (V); 6 -- Crete - Aegean Sea (VI); 7 -- Eastern Mediterranean - Black Sea (VII).

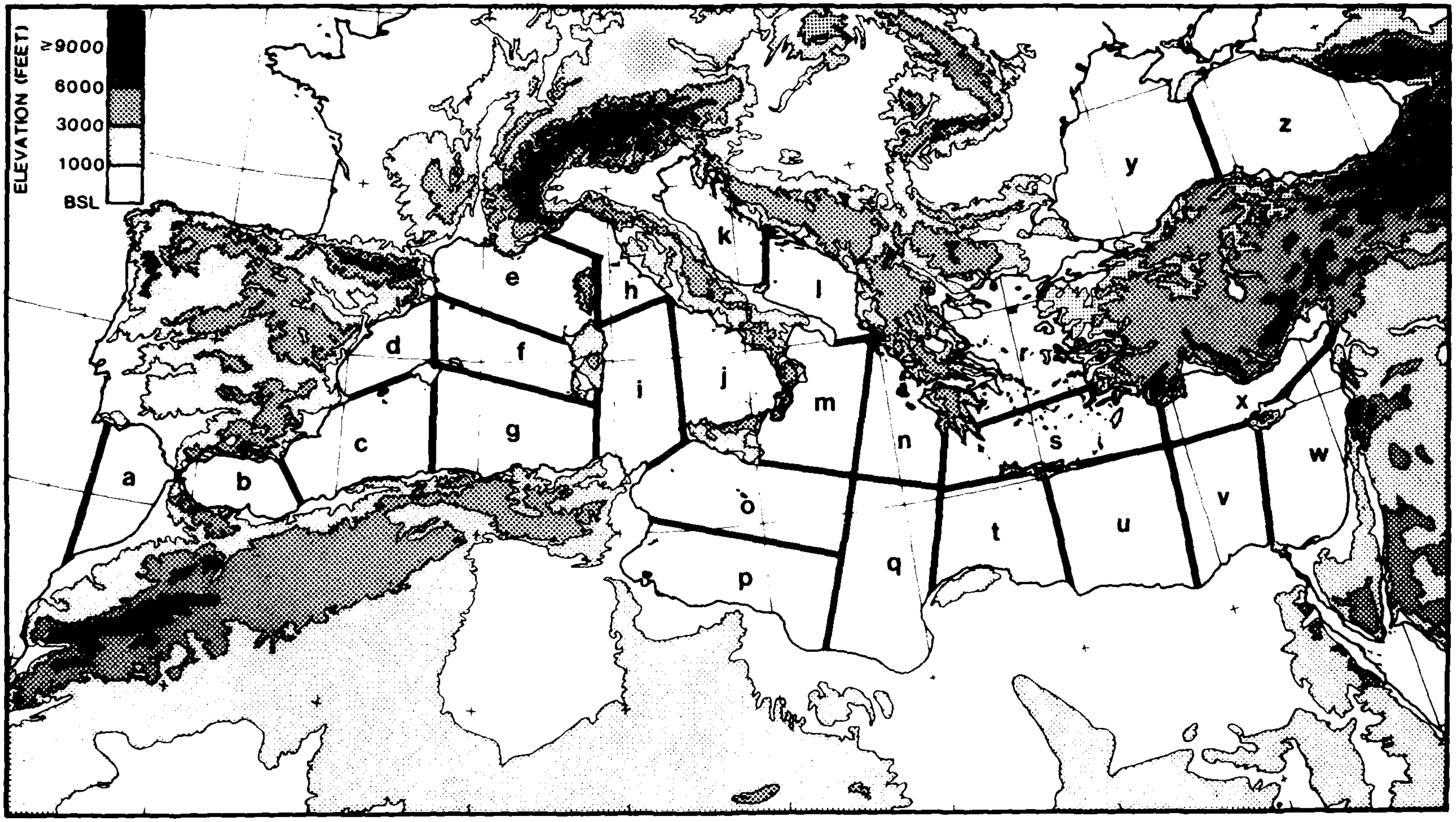


Figure 1b. British nomenclature for forecast sea areas of the Mediterranean and Black Seas: a - Nelson; b - Alboran; c - Oran; d - Valencia; e - Lions; f - Unicorn; g - Bougie; h - Genoa; i - Bonny; j - Volcano; k - Venice; l - Centaur; m - Boot; n - Ionian; o - Melita; p - Gabes; q - Sidra; r - Aegean; s - Jason; t - Bomba; u - Matruh; v - Delta; w - Crusade; x - Taurus; y - Danube; z - Georgia.

Section Content. Each section provides, in sequence, the following information: (1) an overview of the area's geography and seasonal weather patterns; (2) discussions of the weather phenomena common to the area; and (3) a series of forecasting rules. The rules are given in numerical order by type of occurrence and geographical location within the area; locator tables precede the rules to facilitate quick reference.

Each section is designed to stand alone, providing sufficient information for the forecaster concerned with the specific geographical area. This structure necessarily has caused a certain amount of repetition in discussions and rules from one section to the next, insofar as certain weather phenomena occur across two or more adjoining areas. To minimize repetitive discussions of a particular weather feature, the reader occasionally is referred to another section where that feature is a more dominant factor in local weather.

I. GIBRALTAR – WESTERN MEDITERRANEAN AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Gibraltar-Western Mediterranean Area* shown in Figure I-1 is defined to include the region from 9°W to 3°E encompassing the Gulf of Cadiz and a small area of the Atlantic Ocean east of Cape St. Vincent, the Strait of Gibraltar, the Alboran Channel, and the Balearic Sea west of Mallorca.

High mountain barriers dominate both the north and south coasts of this area, especially east of the Strait of Gibraltar. Along the north coast, the major mountain chains are the Sierra Nevada, Sierra de Guder and the Pyrenees; they are separated by the Jucar and Ebro valleys. West of the Strait of Gibraltar along the north coast, the mountain barrier is less pronounced and much farther inland. Along the south coast, the Atlas Mountains dominate both Morocco and Algeria with no major valley gaps. The major geographical feature of this area is the Strait of Gibraltar. Channeling and corner effects dominate the wind flow in this region.

1.2 SEASONAL WEATHER

The seasonal weather patterns of the Gibraltar-Western Mediterranean Area are controlled to a great degree by the movement of the semi-permanent Azores anticyclone.

During the winter season (November through February), the anticyclone retreats as the upper-level westerlies and associated storm track move southward. Migrating cyclones and anticyclones cause the area's weather to be mild, wet, and windy.

During the summer season (June through September), the Azores anticyclone extends northeastward toward the Alps, causing warm and dry weather with light winds over the area. It is at this time of the year that the levante is most common.

The transitional seasons, spring and autumn, are of considerably different length. Spring, which extends from March through May, is noted for periods of stormy, winter-type weather alternating with a number of false starts of settled summer-type weather. Autumn, in contrast, usually lasts only for the month of October and is notable for an abrupt change to the generally stormy winter-type weather.

*Comprises British forecast sea areas Nelson, Alboran, Oran, Valencia; see Figure 1b in the Introduction.

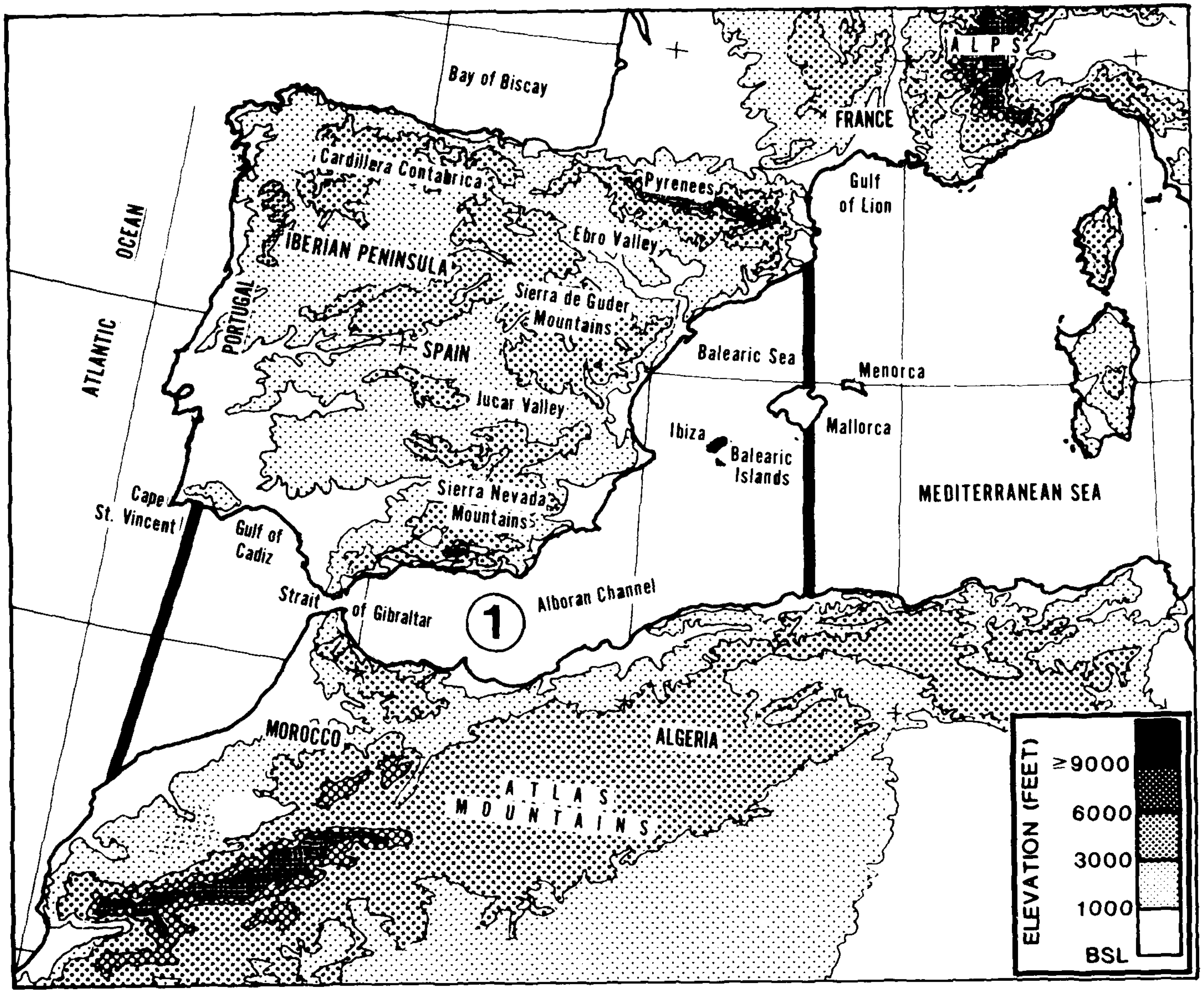


Figure I-1. Topographical map of Gibraltar - Western Mediterranean Area.

2. REGIONAL WEATHER PHENOMENA

2.1 LEVANTE

2.1.1 Introduction

The levante is an easterly or northeasterly wind that occurs in this area from the coast of southern France to west of the Strait of Gibraltar. ("Levanter" is the English name for this wind in the Strait of Gibraltar and Alboran Channel; in this publication, the better known term "levante" will be used exclusively.)

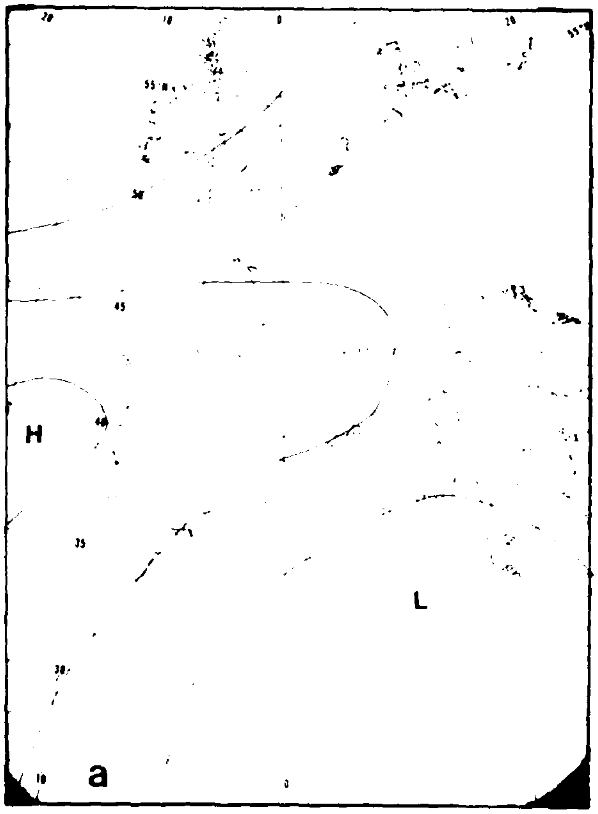
The levante can occur in association with several different weather patterns, as shown in Figure I-2. In the most typical situation, it occurs when the Azores anticyclone extends northeastward over Spain and southern France. With a large anticyclone over western Europe and relatively low pressure over the western Mediterranean, the levante will be widespread. If a high cell is located near the Balearic Islands, however, the levante will be localized in the Alboran Channel/Strait of Gibraltar area. On the other hand, the levante will often precede the arrival of a cold front from the Atlantic during the cool season (November through April) when a lee depression or trough forms in the region off the Balearic Islands. In situations where an intense cyclone is located south of the Balearic Islands, a gale force levante can be expected ahead of the low along the east coast of Spain and over the Balearic Sea.

Occurrence of the levante is the combined result of the following factors:

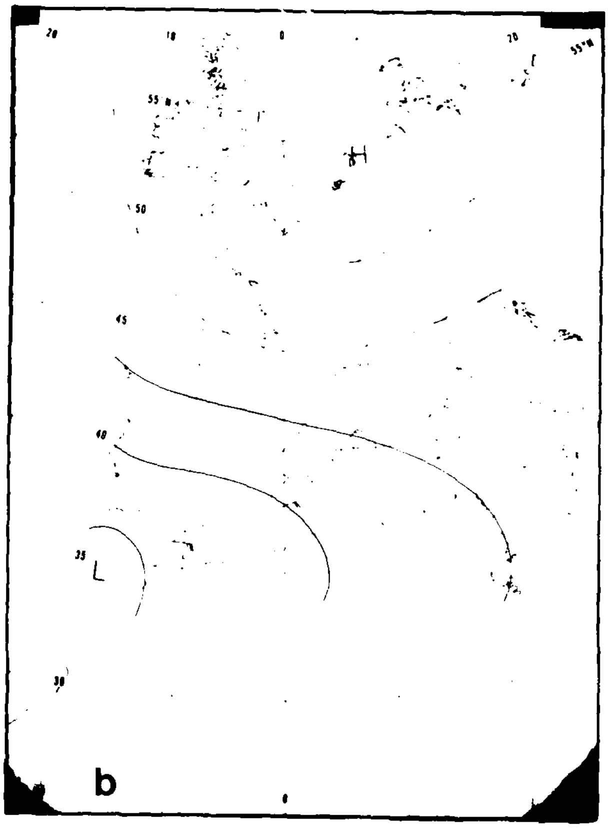
(1) The basic circulation resulting in a surface pressure gradient over this area from northeast to southwest with highest pressure to the north and/or east.

(2) Large-scale channeling of the airflow through the Alboran Channel and Strait of Gibraltar. (The channeling effect produces a much wider variety of localized pressure distributions in association with the levante; e.g., low pressure to the west or south of Gibraltar will cause a levante.)

(3) A local jet-effect increase in the vicinity of the Strait of Gibraltar, caused by the orographic configuration of the two coastlines. (The narrow band of maximum easterlies caused by this effect extends a considerable distance west of the Strait; although this band generally is only about 2 n mi wide, it sometimes can expand to a width of 30 n mi.)

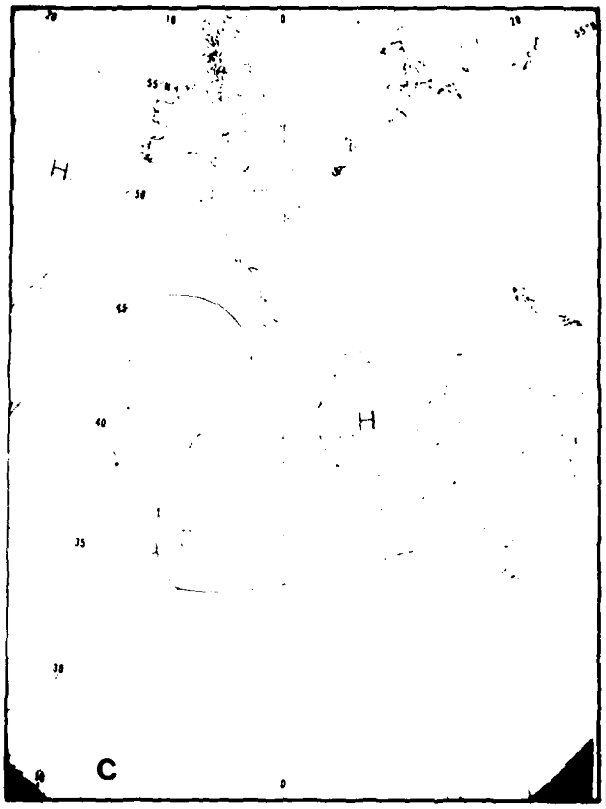


(a) Azores anticyclone extending over
Spain and southern France.

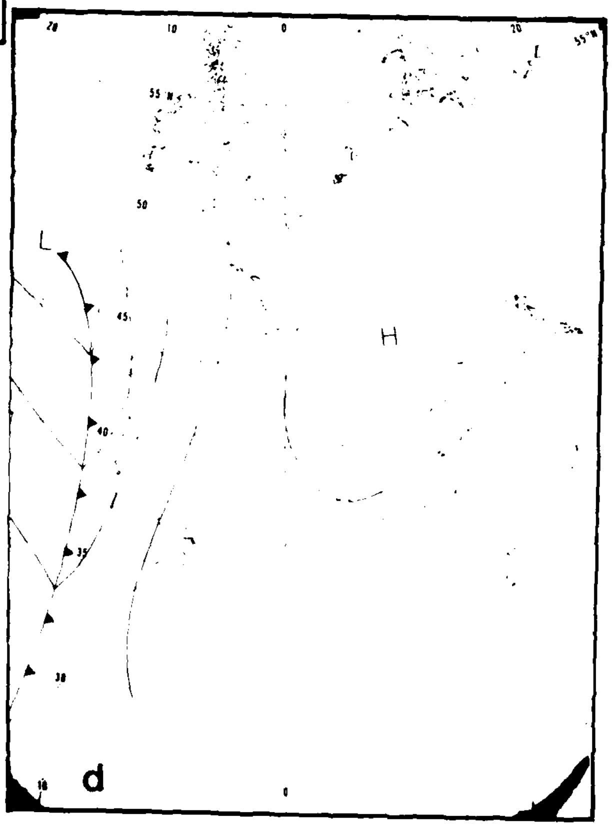


(b) Anticyclone over western Europe and
low pressure over the western
Mediterranean.

Figure I-2. Typical pressure and wind patterns associated with the levante.

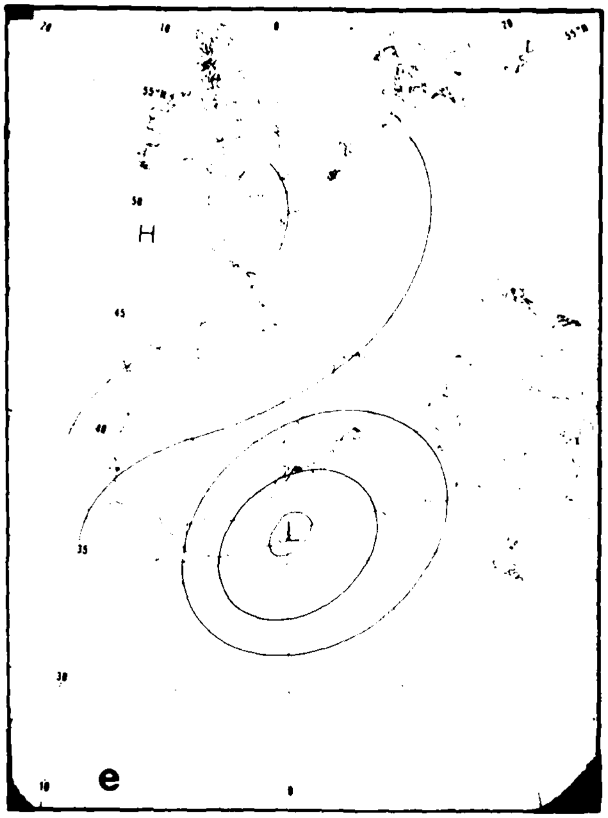


(c) Anticyclone over the Balearic Islands.



(d) Cold front approaching the Strait of Gibraltar from the west.

Figure I-2. Continued.



(e) Intense cyclone south of the Balearic Islands.

Figure I-2. Continued.

2.1.2 Climatological Properties

Intensity. Levante wind speeds are usually moderate (12-25 kt); speeds of greater than 33 kt are rare. In the Alboran Channel and Strait of Gibraltar, however, the large-scale channeling and local jet-effect commonly produce winds of gale force* which usually extend in a narrow band west of the Strait before weakening.

Direction. The direction of the levante is generally between north-northeasterly to east-northeasterly across the western Mediterranean. In the Alboran Channel and Strait of Gibraltar, however, the channeling effect produces an easterly wind.

Seasonal Variations. The levante can occur during any season. In summer, the Azores anticyclone extending over Spain and/or southern France is the typical weather pattern (Figure I-2a). During the other seasons, the levante is usually associated with cyclonic activity over the western Mediterranean, over northwest Africa, or over the North Atlantic west of northern Morocco. A large anticyclone over western Europe can occur from October through April and this will usually produce levante conditions.

*At heights of 100-400 ft, very localized wind speeds of 100 kt can occur; these lessen markedly above mountain top height.

Clouds and Weather. During the summer, the weather associated with the levante is generally good, although extensive haze will often reduce visibilities. In the Strait of Gibraltar, warm air moving over a relatively cool water surface (caused by upwelling in that area) produces frequent fog and low stratus. At the eastern end of the Strait, the levante usually causes heavy dew, and frequently causes mist with occasional drizzle. For this reason, the existence of cloudiness revealed by satellite data and mainly confined to the eastern portion of the Strait, is often an excellent indication that a levante is in progress (see Figure I-3). During the other three seasons, approaching cold fronts or depressions are accompanied by low clouds and frequently heavy rains, reducing visibilities. Heaviest rains appear to occur along the east coast of Spain as a result of orographic effects. If the air mass is cold and unstable, as is the case when cold polar air in association with a cold high over Europe moves across the relatively warm water, convective activity is common.

2.1.3 Special Case: Rota, Spain

Although levante winds occur throughout the year at Rota, they are most commonly associated with the summer season. The normal levante circulation in summer advects Mediterranean air across Spain, where the air is heated and dried both by contact with the warm dry surface and adiabatically in the downslope flow approaching Rota. The channeling effect through the Strait of Gibraltar combined with downslope flow appears to create super-gradient wind speeds.

At Rota, the levante is defined as a wind from the southeast quadrant (100°-160°) of 12 kt or more and persisting for at least five consecutive hours. A typical levante day is characterized by clear skies, low humidities, good visibilities, high temperatures and gusty winds. Winds at the naval air station generally are southeasterly 12-18 kt gusting to 22-28 kt. At the same time in the port area, winds are southeasterly 18-24 kt gusting to 28-34 kt. The levante at Rota exhibits the following characteristics:

(1) It is most frequent in the summer with a peak occurrence during August.

(2) It is often observed on as many as eight consecutive days, although more than half the occurrences last only one day; the shorter durations occur in the winter.

(3) Wind speeds of 12 kt or greater often persist for 60 consecutive hours, commencing normally at about 0900 GMT and ending at about 2200 GMT.

(4) Wind speeds are usually weakest between 0300 GMT and 0700 GMT.

(5) Maximum temperatures usually range from the high 80's to mid 90's (°F). Temperatures above 96°F occur only with non-levante northeasterlies.

Figure I-3. Satellite image showing cloudiness during typical levante conditions.

2.2 WESTERLY WIND REGIMES

2.2.1 Introduction

Strong westerly winds are common in the Gibraltar-Western Mediterranean Area, usually as the result of deep low pressure to the north over the British Isles or depressions moving eastward across the Iberian Peninsula. An anticyclone building into the western Mediterranean from the west or southwest also causes strong westerly winds, especially in the Strait of Gibraltar where a channeling effect occurs.

It is common to differentiate between westerly winds associated with two distinctly different types of air masses. Strong southwesterlies ahead of cold fronts are called the vendaval while the northwesterlies behind cold fronts are called ponientes (particularly in Spain).

2.2.2 Vendaval

Because the vendaval is associated with cyclonic activity, it is most likely to occur during the wet season (November through April). It can be expected that the vendaval will follow the levante in the Gibraltar area during the winter. The intensity of the vendaval is usually gale force (34-47 kt) and occasionally storm force (up to 55 kt) in the Strait of Gibraltar. In the remainder of the Gibraltar-Western Mediterranean Area, the intensity is frequently gale force.

Precipitation associated with the vendaval is usually of the nonconvective type, although showers can occur on occasions. Haze is common with visibilities 3-6 n mi decreasing to 1-2 n mi in rain. The start of precipitation is often delayed 6-12 hr after the start of the vendaval, which may sometimes mislead the forecaster into predicting no precipitation.

2.2.3 Poniente

The poniente, in common with the vendaval, is most pronounced from November through April. However, since it is often associated with high pressure building in from the Atlantic, the poniente can be expected at any time of the year, especially in the Strait of Gibraltar.

The mountain chains located in southern and eastern Spain have an important role in modifying the poniente. Strong northwesterly flow crossing the Sierra Nevada (see Figure I-1) causes a lee trough to develop along the northern shore of the Alboran Channel. This trough has weak winds to the immediate south, along the coast, while gale force southwesterlies develop farther south near the Algerian coast (see Figure I-4a). The same effect is seen over the Balearic Sea during the poniente when strong northwesterly flow crosses the Iberian Peninsula. Under these conditions, a well-defined lee trough develops along the Spanish coast from Barcelona to Valencia (see Figure I-4b) causing winds to be light westerly to southwesterly out to 50 n mi offshore with the expected gale force northwesterlies occurring well to the east.

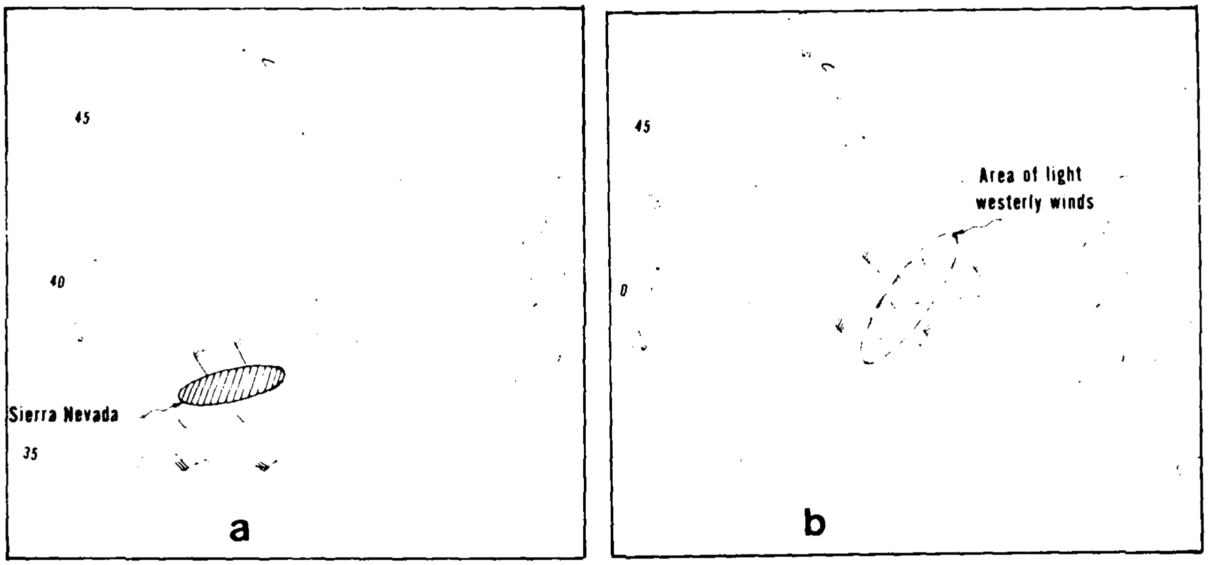


Figure I-4. Winds associated with lee trough development during the *poniente*. (a) lee trough along the northern shore of the Alboran Channel. (b) lee trough along the western shore of the Balearic Sea.

An important exception to the light winds along the coast is at Alicante and at Valencia where strong local winds from 270° to 300° and speeds to 30-55 kt are caused by funnelling through mountain valleys (see Figure I-6 for station locations).

Weather associated with the poniente is usually much better than vendaval weather. Outside of scattered showers with reduced visibilities of 2-5 n mi in showers, skies are generally clear with scattered cumulus clouds and excellent visibilities. The shower activity is most frequent over the water from 2200 GMT to 1000 GMT, and over land from 1500 GMT to 2000 GMT.

2.3 MISTRAL

The mistral is a cold, strong northwesterly to north-northeasterly wind flowing offshore across the entire coast of the Gulf of Lion (see Section II, Para. 2.1). It often extends beyond the Gulf of Lion, affecting the weather not only in the Gibraltar-Western Mediterranean Area but occasionally as far east as Crete.

One effect of the mistral in the Gibraltar-Western Mediterranean Area is the occurrence of a sharp shear line between high and low wind speeds occurring downstream from the eastern edge of the Pyrenees. Winds are typically 35-45 kt to the east and 8-16 kt to the west of the shear line. Another effect of the mistral is its association with the levante: gale force levantes in the Alboran Channel and Strait of Gibraltar are often preceded by a strong mistral in the Gulf of Lion.

Visibilities are generally good in this area during mistral situations. Low cloudiness is sometimes present along the shear line; during storm force mistrals, very poor visibilities can occur (east of the shear line) up to a height of 100 ft as a result of blowing spray.

2.4 SIROCCO

The sirocco is a southeasterly to southwesterly wind over the Mediterranean that originates over North Africa. This source region is over deserts and thus the sirocco is extremely dry; it is warm in winter, and hot in spring and summer. Its influence occasionally extends over the entire Mediterranean basin, but is most pronounced in the Gulf of Gabes east of the Atlas Mountains.

In the Gibraltar-Western Mediterranean Area, the sirocco usually occurs in the warm sector of cyclones located north of the area. Near the North African coast, the sirocco blows on the average four to five times per month, most frequently in late spring and early summer. The sirocco winds are usually light to moderate, but often quite gusty; gale force winds occasionally occur.

Weather associated with the sirocco may include blowing dust near the north coast of Africa, and low stratus and fog nearer the Iberian Peninsula (the result of the wind's acquiring moisture over the relatively cool water surface). During a gale force sirocco, visibilities are often reduced to a few yards in dense clouds of dust; as it moves over the Mediterranean waters, this dust tends to support development of haze and/or salt haze. (The sirocco is discussed further in Para. 2.1 of Section V.)

2.5 CYCLONE OCCURRENCES

Cyclonic activity affecting the Gibraltar-Western Mediterranean Area usually originates in one of the following locations shown in Figure I-5:

(1) West of the Strait of Gibraltar

(2) North Africa, south of the Atlas Mountains (North African cyclones)

(3) Balearic Sea, off the east coast of Spain

(4) Bay of Biscay

Cyclones approaching the Strait of Gibraltar present a problem from fall through spring. Generally these systems move southeastward into North Africa where they may regenerate south of the Atlas Mountains. Approximately one third of these storms that approach the Strait appear to redevelop over the Alboran Channel and then move eastward into the western Mediterranean.

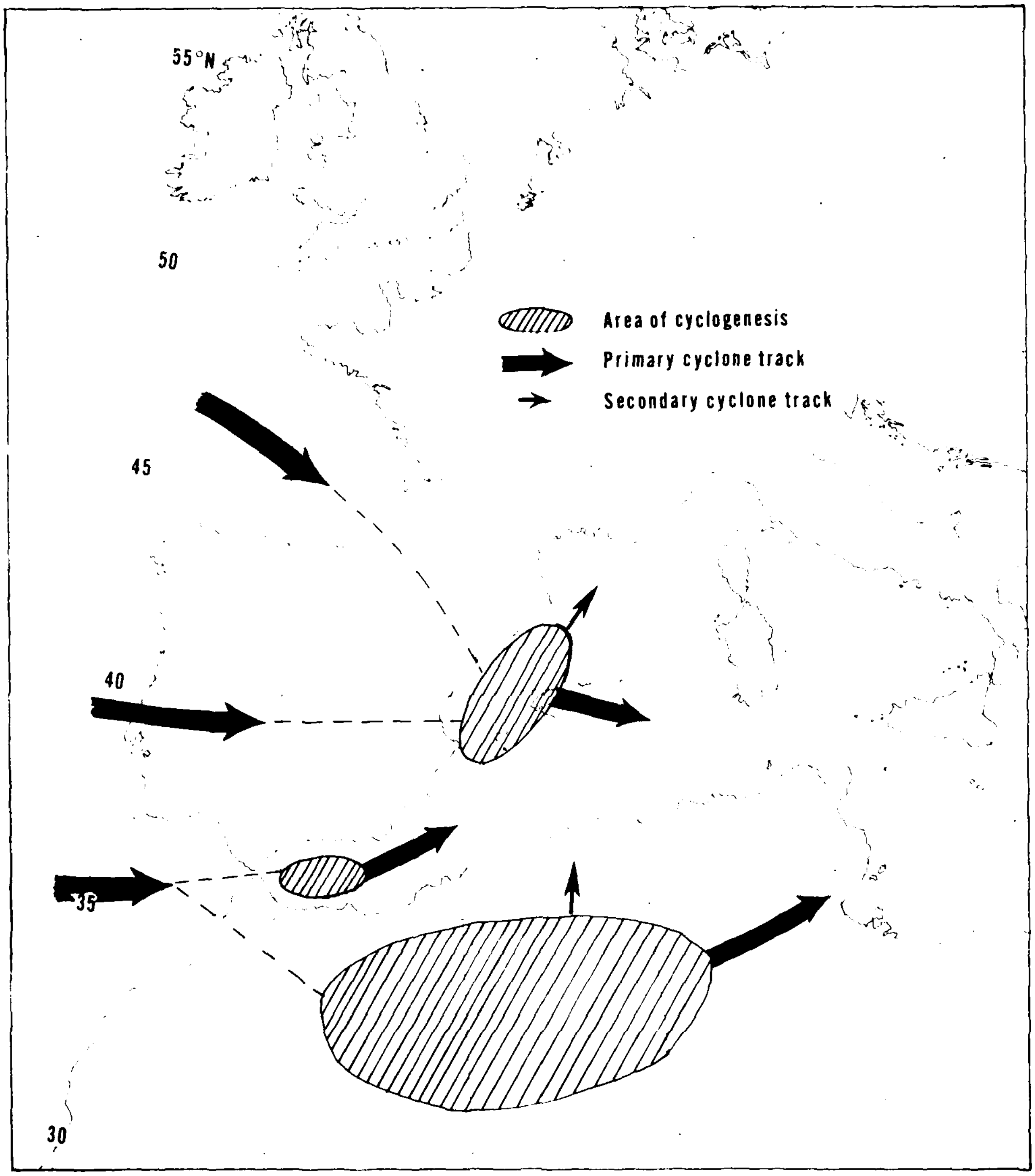


Figure I-5. Areas of cyclogenesis and tracks of cyclones which affect the Gibraltar - Western Mediterranean Area.

The North African cyclone (described in detail in Para. 2.5 of Section V) is most common during the winter and spring. It generally moves eastward south of the Atlas Mountains, recurving northeastward over the Mediterranean after reaching the Gulf of Gabes. It is only on those rare occasions when the cyclone moves northward across the Atlas Mountains that it directly affects this area. However, with a North African cyclone over Morocco or western Algeria, strong levante winds can be expected over the Alboran Channel and in the Strait of Gibraltar. If there are strong upper level south-southwesterlies across the Atlas Mountains, lee cyclogenesis can be expected over the sea area north of the mountains. These secondary systems can be quite intense, but they usually decay as soon as the parent low moves to the east.

Cyclogenesis over the Balearic Sea is most common during winter, but it can also occur during spring and autumn. Cyclogenesis appears to be associated with two marked types of upper-level flow patterns.

The first type, which results in approximately 15 of the cyclogenesis over the western Mediterranean basin, is marked by strong zonal flow south of 45N. Depressions moving eastward across the Iberian Peninsula are observed to weaken as a new center rapidly develops in a lee trough off the east coast of Spain. In some of the more intense situations, southerly winds reaching 30-40 kt with gusts to 60 kt in the warm sector of the developing low are observed. Sea conditions can be quite rough, especially after the passage of the depression, when southwesterly to southerly swells meet with northerly and northwesterly wind-induced sea state.

The second type of pattern, which produces cyclogenesis over the Balearic Sea, is the occurrence of upper-level northwesterly flow crossing the Cardillera Contabrica and Pyrenees from the Bay of Biscay. Development in these cases is associated with cyclones over the Bay of Biscay moving eastward or southward, and does not appear to be as intense. Movement of these systems is very slow with a tendency to drift northward, over the Gulf of Lion, before dissipating.

3. FORECASTING RULES

Tables I-1 through I-5 provide quick reference to the 89 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location within the area of interest. Observing station locations are shown in Figure I-6, and listed in Table I-6.

Table I-1. Forecasting rules for the levante.

Onset	Rules 1-3
Intensity	Rules 4-6
Restriction to Visibility	Rule 7
Special Wind Phenomena	Rules 8,9
Sea State	Rule 10
Cessation	Rule 11
Additional Levante Rules for Rota and Gibraltar	See Table I-5

Table I-2. Forecasting rules associated with surface westerlies.

Onset	Rules 12,13
Intensity	Rules 14-16
Alboran Channel	Rules 17,18
Balearic Sea	Rule 19
Strait of Gibraltar	Rule 20
Westerlies at Gibraltar	See Table I-5

Table I-3. Forecasting rules for cyclonic activity.

Gibraltar Area	West of Strait	Rules 21,22
	East of Strait	Rules 23,24
North Africa		Rule 25,26
Balearic Sea		Rule 27
Miscellaneous		Rules 28,29

Table I-4. Miscellaneous rules for Gibraltar-Western Mediterranean Area.

Mistral		Rules 30,31
Gibraltar Area		Rules 32,33
Altantic Ocean Area		Rules 34,35
Fronts		Rules 36,37
Station Reports	SFC Wind	Rules 38,39
	SFC Pressure	Rule 40
	Upper Air	Rule 41
Fog		Rules 42,7
Haze		Rules 43-45,7

Table I-5. Forecasting rules for ports and anchorages in Gibraltar-Western Mediterranean Area.

Rota	Levante	Rules 46-52
	Fog/Stratus	Rules 53-57
	Precipitation	Rules 58-60
	Other	Rules 61,62
Gibraltar	Diurnal Effects	Rules 63,64
	Precipitation	Rules 65-69
	Wind	Rules 70-77
	Fog	Rules 78-80
	Other	Rules 81,82
Barcelona		Rules 83-85
Palma		Rule 86
Tangier		Rule 87
Valencia		Rules 88,89

Table I-6. List of observing stations.

Name of Station	Block No.	Index No.
Alboran	08	490
Alcoy	08	357
Alicante	08	359
Almeria	08	488
Badajoz/Caceres	08	261
Barcelona	08	181
Bordeaux	07	510
Bougie	60	402
Casablanca	60	155
Funchal	08	521
Gibraltar	08	495
KILO (4YK)	47°N, 17°W	
Lisbon	08	536
Madrid	08	221
Mahon	08	314
Malaga	08	482
Oran	60	490
Palma	08	302/306
Paris	07	149/150
Perpignan	07	747
Rota	08	449
Santa Cruz de Tenerife	60	020
Sevilla	08	390/391
Tangier	60	101
Tarifa	08	458
Taza	60	127
Valencia	08	285
Zaragoza	08	161

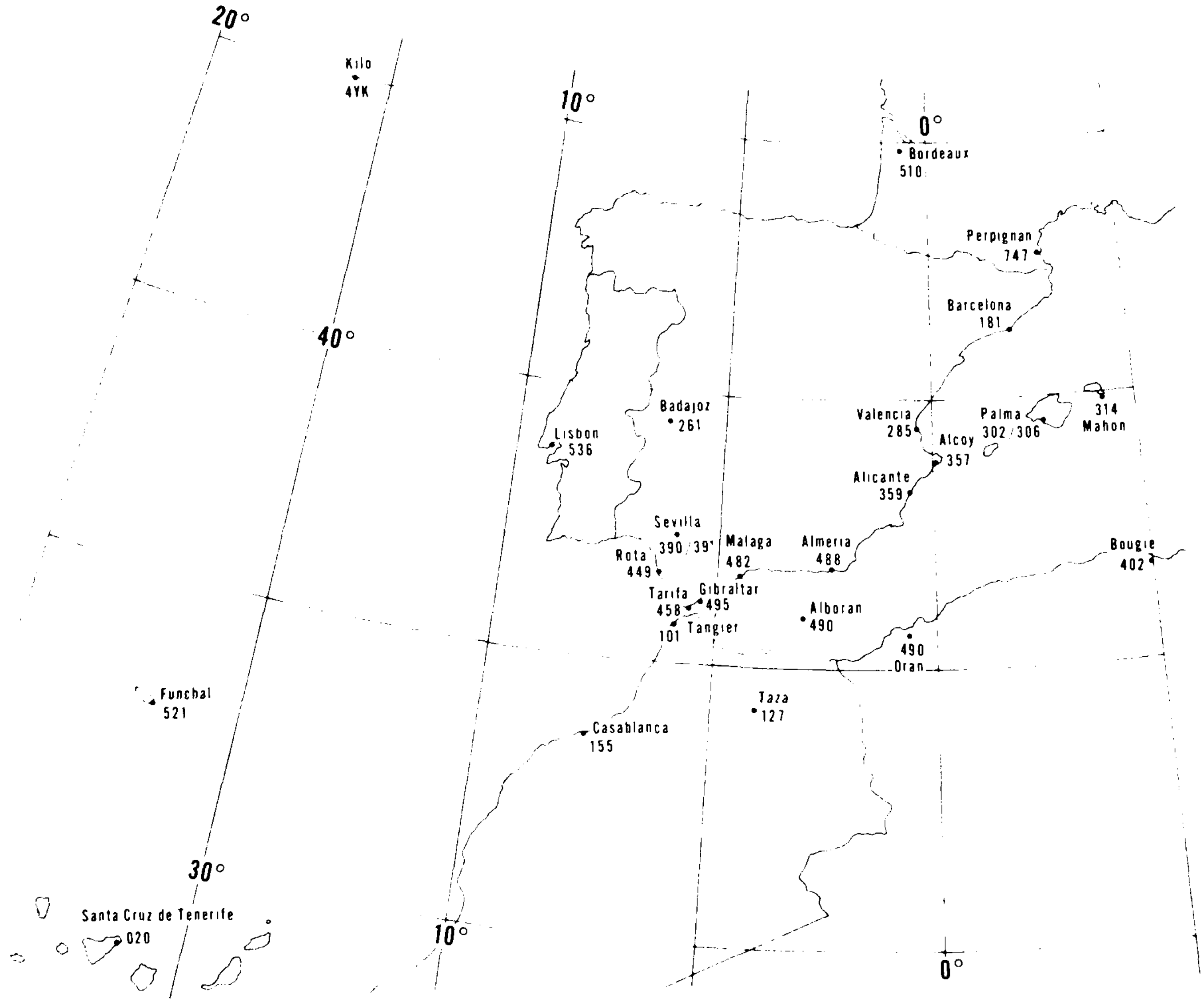


Figure I-6. Station locator map for the Gibraltar - Western Mediterranean Area.

LEVANTE, ONSET, RULES 1-3

1. Forecasting sudden onset of levante conditions in the Gibraltar area during the summer requires the tracking of old cold fronts as they move southwestward along the coast of Spain. Movement of these cold fronts can be followed by observing changes in humidity and wind direction from the normal sea breeze at coastal stations (see Figure I-6). Two very useful stations are Alicante and Malaga. (Note that Almeria is too far from the coast to be useful in these situations.)

2. A gale force levante in the Strait of Gibraltar will commence when northwesterly winds at 300 mb over central and southern Spain veer to 040°.

3. Stratus, common along the coast of Portugal, is normally pushed approximately 100-200 n mi off the coast at the start of a levante in the Rota area. At times this movement precedes the levante and thus should be watched closely as an indicator of levante onset.

LEVANTE, INTENSITY, RULES 4-6

4. Strong levante winds in the Strait of Gibraltar occur when the pressure difference, Malaga minus Rota, is 4 mb or more. A 4 mb difference will produce levante winds of 30-35 kt in the Strait.

5. During levante conditions in the Strait of Gibraltar, easterly winds at two stations -- Tarifa and Taza give a close approximation of the winds in the Strait.

6. During levante conditions, double the wind speed readings of sustained easterly winds at Gibraltar for a close approximation of the maximum wind speed in the Strait of Gibraltar.

LEVANTE, ASSOCIATED PHENOMENA, RULES 7-10

7. The heaviest concentrations of low stratus, fog, and haze during levante conditions are found in the Alboran Channel south of 36°N (see Figure I-3).

8. During levante conditions in the Strait of Gibraltar, the area of maximum easterly winds is normally quite narrow, only about 2 n mi wide. This band of strong winds has been observed to extend 60 n mi westward of the Strait north of 36°N. A basic easterly airflow of about 15-20 kt produces a maximum band of 35 kt winds.

9. During levante conditions through the Strait of Gibraltar, an eddy in the low-level flow is found west and south of the Strait. This eddy is at times distinguishable in the low clouds on satellite imagery (see Figure I-3). A cold ocean eddy is also sometimes noted in the same area.

10. Levante conditions in the Strait of Gibraltar can produce very high sea states.

LEVANTE, CESSATION, RULE 11

11. Forecast a levante to end, especially in the Strait of Gibraltar-Alboran Channel area, when a depression passes across either the British Isles or France and its cold front begins to cross the Iberian Peninsula. Since westerlies replace easterlies while the front is some distance to the north, the front need not progress as far south as Gibraltar for the levante to cease.

WESTERLY WIND REGIMES, ONSET, RULES 12, 13

12. Gale force westerly winds in the Alboran Channel generally occur after the upper-level trough has moved east of that area.

13. Strong and gusty northwest winds along the Spanish coast between Barcelona and Valencia are common following the passage of an upper-level trough. An advanced warning (3-6 hr) might be obtained from Zaragoza in the Ebro Valley.

WESTERLY WIND REGIMES, INTENSITY, RULES 14-16

14. Strong westerly winds occur in the Strait of Gibraltar when the pressure difference, Rota minus Malaga, is 4 mb or more. A 4 mb difference will produce 30-35 kt westerly winds in the Strait.

15. Although no formal study has been made, local forecasting experience would indicate that there is a relationship between westerly winds in the Strait of Gibraltar and the wind at Tangier.

16. Because of orographic features to the west of Gibraltar westerly winds at this station correlate poorly with winds in the Strait of Gibraltar.

WESTERLY WIND REGIMES, HORIZONTAL VARIATION, RULES 17-20

17. During periods of westerly surface flow in the Alboran Channel, it has been observed that wind speeds are approximately two Beaufort wind scale numbers (10 kt difference at a speed of 30 kt) greater along the North African coast than elsewhere in the area.

18. During periods of strong northwesterly flow over Spain, a lee trough will develop along the south coast of Spain (see Figure I-4a); this will cause winds over the Algerian coast to be gale force southwesterly.

19. During periods of strong northwesterly flow over Spain, especially following a cold frontal passage, a well defined lee trough can be expected to form along the coast from Barcelona to Valencia (see Figure I-4b). Associated with this trough, light west or southwest winds occur out to 50 n mi offshore, while the normal strong northwesterly flow occurs beyond that. For example, a synoptic pattern that might have reasonably been expected to give rise to northwesterly winds of 17-22 kt often produces in the region of the lee trough southerly to westerly winds 5-20 kt.

20. The strongest westerly winds in the Strait of Gibraltar are observed over the southern part of the Strait.

CYCLONIC ACTIVITY, GIBRALTAR RULES 21-24

21. Cold fronts approaching the Rota area from the west (oriented N-S) will usually lead to cyclogenesis in the Gulf of Cadiz if, as the front reaches 20-30°W, it extends southward to 30-35°N (see Figure I-7).

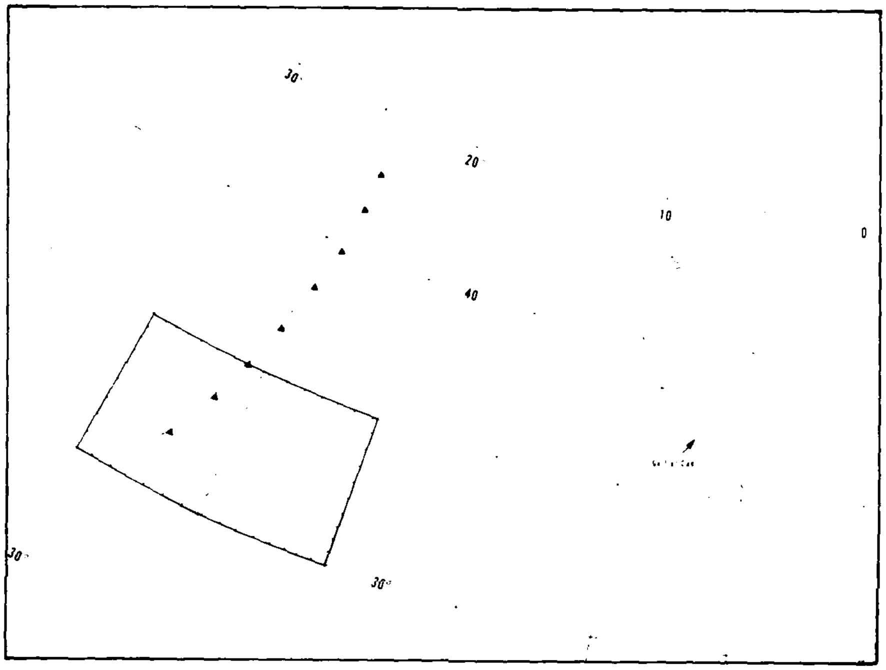


Figure I-7. Area (shaded) in which a N-S oriented cold front must pass through if new cyclogenesis is to be expected along the front when it reaches the Gulf of Cadiz.

22. Cut-off lows are major weather producers in the Gibraltar area. A good indicator of a developing cut-off low is the 300 mb wind at ship station KILO. If the 300 mb wind at KILO becomes northeasterly (approximately 040°) and greater than 30-40 kt, a cut-off low can be expected to develop. These lows remain stationary for up to 7-10 days. Indicators of eastward movement of the low are winds becoming more westerly to the north of the Azores.

23. Surface lows approaching the Strait of Gibraltar from the west appear at times to move discontinuously from west of the Strait into the Alboran Channel. Approximately 30% of cyclones will do this, while the others will generally move southeastward into North Africa or northeastward into Iberia.

24. The 700 mb wind is a good indicator of movement of a surface low approaching the Strait of Gibraltar. If the 700 mb wind backs to 210° at Gibraltar a surface low can be expected to redevelop (intensify) east of the Strait. When this type of movement is forecast, gale force easterly winds can be expected to cease as the cyclogenesis occurs east of Gibraltar.

CYCLONIC ACTIVITY, NORTH AFRICA, RULES 25, 26

25. North African cyclogenesis is most often associated with a 500 mb trough oriented NNE-SSW from the vicinity of Paris to the west coast of North Africa. Although not a necessary requirement, chances for cyclogenesis increase if both the polar front jet (PFJ) and subtropical jet (STJ) are present.

26. If a 500 mb trough is cut off over southern Algeria and Morocco, vigorous local surface depressions with gale force easterly winds are likely to form north of the Atlas Mountains as a result of lee effects. These depressions generally remain localized except when a further incursion of cold air from the north reinvigorates the upper-level trough; when this occurs, rapid cyclogenesis is likely.

CYCLONIC ACTIVITY, BALEARIC SEA, RULE 27

27. Surface cyclones generally weaken while traversing the Iberian Peninsula. These lows deepen rapidly, however, when they reach the east coast of Spain.

CYCLONIC ACTIVITY, MISCELLANEOUS, RULES 28, 29

28. In the Mediterranean region it is important to track the remnants of old cold fronts closely. Several cases have been documented in which cyclogenesis originated along one of these fronts -- even after the cloudiness associated with these fronts had disappeared -- when an upper-level, short-wave trough (SD minimum) has approached from the west.

29. Periods of gale force northeasterly winds (speeds up to 40 kt) occur off the east coast of Spain as far as Ibiza when a migrating low moves over southern Spain into the area west of the Greenwich Meridian.

MISCELLANEOUS RULES, MISTRAL RULES 30, 31

30. The following properties are associated with the western boundary of the mistral:

(1) The boundary is extremely narrow, 2-20 n mi wide.

(2) Large changes in wind and sea conditions are observed across the boundary. Winds 8-16 kt typically are found to the west of the boundary; winds 35-45 kt are found to the east of it. Sea heights typically are 3-5 ft to the west, when heights are 14-20 ft to the east.

(3) The western boundary of the mistral appears to move generally from east to west, especially in the region of the Balearic Islands. At times it oscillates from southwest Mallorca to northeast Menorca.

(4) The boundary occasionally is marked by a line of convective cloudiness (see Figure III-3); otherwise it is clear and can only be observed by marked changes of wind speed over the surface of the sea.

(5) A relatively accurate location of the boundary is a line drawn to the North African coast through three stations: Perpignan, Mahon, and Bougie.

31. During strong mistral conditions in the Gulf of Lion, a strong diurnal wind variation has been observed in the sea area north of Mallorca, possibly the result of oscillation of the shear line described in Rule 30. Wind speeds appear to be more than twice as strong during the day as at night. In an actual case, winds of 10-20 kt were observed during the day, decreasing to 4-6 kt during the night.

MISCELLANEOUS RULES, GIBRALTAR AREA, RULES 32, 33

32. Forecast another band of precipitation in the Gibraltar area when the upper-level trough passes eastward across the area.

33. In the Gibraltar area, thundershower activity is common during periods when the 5000-10,000 ft winds over Morocco are from the southwest. These thunderstorms appear to develop over the mountains of Morocco and to move to Gibraltar before dissipating.

MISCELLANEOUS RULES, ATLANTIC OCEAN AREA, RULES 34, 35

34. During the late summer and early autumn the Intertropical Convergence Zone (ITCZ) frequently moves far to the north of its expected position, allowing tropical disturbances to form off the northwest African coast. These disturbances, which affect the Rota area, normally move westward and weaken.

35. High pressure over the Bay of Biscay leads to the formation of an inverted trough off the west coast of Spain and Portugal. Northerly winds of 20-30 kt develop along this coastline, building sea heights 8-10 ft. Divergence or "fanning out" of the isobars, west of the Gulf of Cadiz, causes winds to lessen, but with only a slight decrease in sea heights.

MISCELLANEOUS RULES, FRONTS, RULES 36, 37

36. Shallow cold fronts approaching the Mediterranean basin are greatly retarded by the mountain barrier. Deep cold fronts (i.e., those fronts detectable at the 700 mb level) are not hindered by terrain features and at times are seen to accelerate. Movement of troughs at the 400 mb level appears to be useful in forecasting this acceleration.

37. Correct placement of fronts is very difficult in the western Mediterranean basin due both to the lack of ship reports and to terrain effects. These problems are accentuated during the summer when fronts are weakest. The worst locations in this respect are the Iberian Peninsula and the Balearic Sea. Forecasters should be aware of the lee trough which develops along the east coast of Spain during periods of northwesterly flow: there is a tendency to designate this trough as frontal, instead of correctly moving the front eastward out of the region.

MISCELLANEOUS RULES, STATION REPORTS, RULES 38-41

38. Wind speeds reported at the island station of Alboran appear to be representative of wind speeds over the surrounding sea area.

39. Wind speeds observed at Alcoy are generally higher than those observed in the surrounding sea area.

40. In the past, some forecasting confusion has been prompted by pressure tendency readings from Palma in the Balearic Islands. During the period from late winter through spring, large pressure falls (approximately 2 mb/3 hr) at Palma at the 0300 GMT observation have been misleading. The pressure falls apparently were a local effect, and not indications of cyclogenesis. Mahon readings appear to give more reliable information as far as the potential for cyclogenesis is concerned.

41. Upper-level wind and height data from two radiosonde stations in the eastern Atlantic -- Funchal, Madeira, and Santa Cruz de Tenerife, Canary Islands, (see Figure I-6) -- occasionally are unreliable.

MISCELLANEOUS RULES, FOG, RULE 42

42. Likely areas for occurrences of fog during the summer are along the North Africa coast from the Strait of Gibraltar to Tunisia, in the Alboran Channel, and along the southern Spanish coast.

MISCELLANEOUS RULES, HAZE, RULE 43-45

43. The occurrence of salt haze is a serious problem for flight operations over the Mediterranean. This type of haze has the following properties:

(1) It is most prevalent during the summer and early autumn.

(2) Its color ranges from bluish white to light yellow, as opposed to brown for dust haze.

(3) Salt haze scatters and reflects light much more than dust haze.

(4) It sometimes extends upwards to over 12,000 ft and has been reported at 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi, the slant visibilities for a pilot making a landing approach may be near zero; this is especially true if the line of view is in the general direction of the sun.

(6) Salt haze is sometimes thicker aloft than at the surface.

(7) The haze is less of a problem after sunset because its associated poor visibility is caused partially by scattering and reflection.

44. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing, such as occurs when there is a strong ridge present both at the surface and aloft.

45. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. However, visibilities will improve if there is an increase in the wind speed at the 850 and/or 700 mb levels. (Note: In summer, a yellowish haze will be seen over the eastern Mediterranean nearly all the time.)

RULES FOR PORTS AND ANCHORAGES, ROTA, RULES 46-62

46. The following established technique is used to forecast levante conditions at Rota:

Data required

(1) 00Z 850 mb winds from Gibraltar, Casablanca and Lisbon.

(2) 00Z sea level pressures from Barcelona, Malaga and Rota.

(3) 00Z sea level pressures from Barcelona, Malaga and Rota.

(4) 00Z 500 mb heights from Gibraltar and Bordeaux.

Procedures

(1) Predictor 1. Using a plotting or maneuvering board, determine the resultant of the three 850 mb winds.

(2) Predictor 2. Subtract the 500 mb height at Bordeaux from that at Gibraltar to determine the 500 mb height gradient (tens of meters).

(3) Predictor 3. Use Figure I-8 to determine the east component of the 850 mb wind at Gibraltar (in kt).

(4) Predictor 4. Subtract the sea level pressure at Rota from that at Barcelona and Malaga, using the greater of the two to determine the sea level pressure gradient (mb).

(5) Enter predictors 1, 2 and 3 in Figure I-9, and determine the respective factors. Sum the factors.

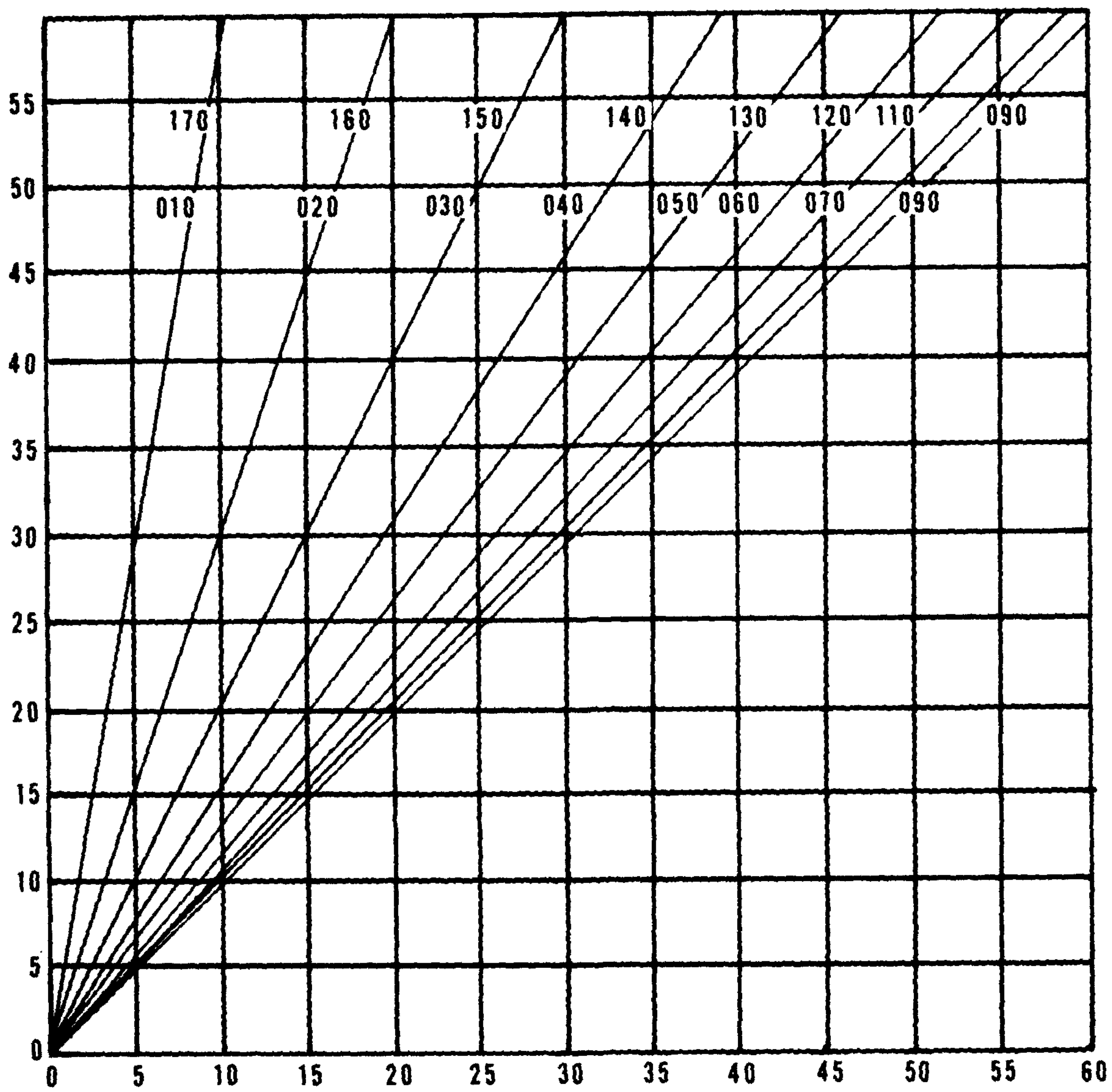


Figure I-8. East component of the wind. To obtain the east component of the wind, enter the nomogram with the wind speed at the left. Find the intersection of this speed value with the appropriate wind direction line (sloping lines). Read the east component vertically from this point of intersection.

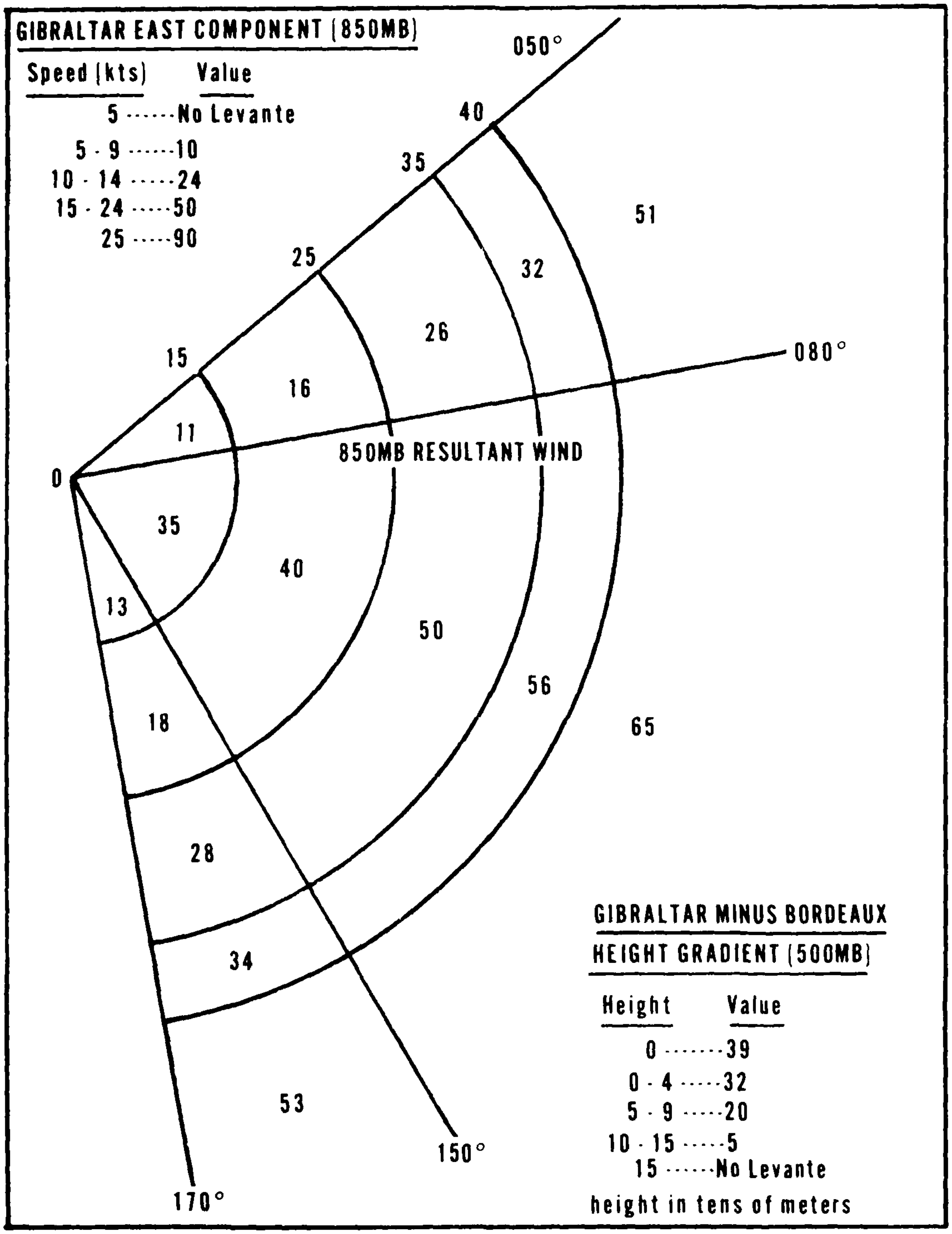


Figure I-9. Levante predictor values.

(6) Forecast levante if the sum is greater than 90 and if none of the following exist:

(a) The Barcelona-Rota and Malaga-Rota pressure gradient is negative.

(b) The resultant is less than 055° or greater than 170°.

(c) The Gibraltar 850 mb east component is less than 5 kt.

(d) The 500 mb gradient between Gibraltar and Bordeaux is greater than 150 meters.

47. The strength of the levante can be approximated by using the pressure difference, Palma minus Casablanca. A +6 mb difference is associated with levante conditions (15-25 kt easterlies) in the Strait of Gibraltar. A +8 mb difference is associated with gale force (>33 kt) easterlies in the Strait and levante conditions at Rota.

48. The pressure difference, Malaga greater than Rota, is related to levante conditions - although not as directly as the Palma/Casablanca pressure difference. A 3 mb difference indicates levante conditions in the Strait of Gibraltar. A 5 mb difference is associated with easterly gales in the Strait of Gibraltar and levante conditions at Rota.

49. During periods of levante in the vicinity of Rota, even when winds are not actually blowing at the station, a nocturnal low-level jet is usually present. This jet, found between 1000-3000 ft, has wind speeds up to 50 kt and usually marks the top of a temperature inversion.

50. The end of levante conditions at Rota is often related to the disappearance of a surface trough west of Rota.

51. Diurnal wind variations during levante conditions at Rota are: maximum wind speeds 1500-2100 GMT during late spring and early summer; minimum wind speeds 0100-0500 GMT during late spring and early summer; and reduced diurnal variations in August and September.

52. During levante conditions at Rota, a weak upper-level trough is usually present to the southwest of Rota. This upper-level trough appears to reinforce the surface trough off the coast - a necessary condition for the levante at Rota.

53. A composite of typical, idealized fog conditions includes mostly light (less than 7 kt) northeasterly surface winds at Rota, saturation or near-saturation at the surface, and strong surface inversion.

Forecast at Rota the likelihood of:

(1) Heavy fog if the clear skies, light winds and saturation conditions exist or are forecast to occur; and 0100 GMT pilot balloon sounding shows southwesterly winds above the low-level drainage layer (northeasterly surface wind), indicating the presence of the strong surface inversion.

(2) Light fog, if the clear skies, light winds and saturation conditions exist or are forecast to occur; and no strong inversion or no definite low-level wind shift exists.

(3) Morning fog, if the above conditions are borderline, but the relative humidity was 60% or greater at 1200 GMT the previous day.

54. Forecast stratus at Rota if:

(1) The thermal low over Spain is centered near Badajoz/Caceres and is enclosed by two or more isobars (2 mb intervals). This applies to summer conditions.

(2) The 850 mb wind at Gibraltar is 20 kt or more from the south-southwest octant.

55. Fog is common at Rota preceding the passage of a cold frontal trough during the winter half of the year. This fog is most likely to occur during the night or early morning with light southerly winds.

56. Fog formation during late spring and early summer at Rota often occurs following a levante. Generally, fog occurs by the next morning with light southerly winds (5-10 kt). This fog appears to form initially off the northwest coast of Africa before moving into the Rota area. Visibilities decrease to about 1 n mi during early morning, improving during the day as the fog lifts. These conditions persist as long as the southerly flow is present.

57. Fog at Rota during spring and early summer can be expected by morning if the normal sea breeze (see Rule 61) backs to 210-220° in the late afternoon. However, it is also important that the position of the thermal trough remain stationary over western Iberia so that the wind will persist from the south throughout the night.

58. Forecast rain at Rota if the Gibraltar rawinsonde shows the following conditions during the period 1 October through 15 May:

Level	Wind Direction	Speed
850 mb	180-255°	≥20 kt
500 mb	180-225°	≥50 kt

59. Shower activity can be expected to occur in the Rota area when a surface cyclone is located between 34-39°N and 9-14°W. The convective activity most common in this case during the spring develops over the mountains of northwest Morocco, then moves in the upper-level southwesterly flow to Rota.

60. A composite of typical, idealized thunderstorm conditions at Rota includes the following, listed in order of significance:

(1) Heights of the 500 mb level, as reported by the Gibraltar sounding, below 18,602 ft in winter, 18,635 ft in spring, 19,389 ft in summer, and 18,963 ft in autumn.

(2) Wind speeds of 50 kt or more at the 500 mb level and 100 kt or more at the maximum wind level.

(3) West quadrant (215° to 295°) wind directions at the 500 mb and maximum wind levels.

(4) Stability index of +4 to -4.

(5) Cold frontal passage from the west quadrant within 24 hours.

(6) Autumn or winter season.

Forecast thunderstorms at Rota when conditions (1), (2), (3), and either (4) or (5) exist or are forecast to occur.

61. From May to September, a land-sea circulation dominates the local winds at Rota. The sea breeze is southwesterly, perpendicular to the general coastline, veering to westerly after 1500-1600 LT. The strength varies with the thermal gradient in the range 8-14 kt. The opposing land breeze is northeasterly at an average 3-6 kt. The sea breeze normally starts between 1100 LT and 1300 LT. In general, northerly or northwesterly winds back to westerly, and easterly or southeasterly winds veer to southwesterly. Northeasterly winds may shift either way.

62. The hottest weather at Rota during the summer does not occur during the levante, but rather during periods of light northeasterly flow. Although these conditions normally precede the start of a levante by one day, they also may occur at other times.

RULES FOR PORTS AND ANCHORAGES, GIBRALTAR, RULES 63-82

63. Regarding sea breezes at Gibraltar:

(1) Sea breezes, usually summer phenomena, are winds from 160° to 210° with speeds of 5 kt or more that persist for at least one hour.

(2) It has been observed that half of the sea breeze occurrences at Gibraltar begin by 0930 LT.

(3) Three-fourths of the sea breeze occurrences at Gibraltar have had depths below the rock-top level (1400 ft).

(4) Mean speeds of fully developed sea breezes are approximately 15-20 kt with gusts to 25-28 kt.

(5) Early morning conditions favoring the development of a sea breeze at Gibraltar include clear or almost clear skies; and westerly winds at 2000 ft, less than 23 kt, or easterly winds at 2000 ft, less than 1[illegible] kt.

(6) Figure I-10 is a schematic of the sea breeze circulation in the area surrounding Gibraltar, for the case with 2000 ft winds from the west. Temperature increases of up to 8°C in one hour, with the onset of the sea breeze, are caused by air being drawn into the circulation from Spain. The temperature rise does not occur with easterly winds at 2000 ft, since the circulation is different.

(7) Guides for forecasting sea breezes associated with the pressure difference, Casablanca minus Alicante:

Difference	Forecast
Less than -2 mb	No sea breeze
-2 to -1 mb	Small probability of sea breeze
0 to 6 mb	High probability of sea breeze
7 mb	Small probability of sea breeze
8 mb or more	No sea breeze

64. Katabatic winds affecting Gibraltar are usually westerly at night; if the general flow is easterly at 10 kt or more, however, the winds increase from the east between 0100 GMT and 0200 GMT due to an easterly katabatic wind.

Rules 65-69 are based on conditions at 0000 GMT for forecasts of rain at Gibraltar and are valid for 24 hours; intensity of rain is not included.

65. Forecast rain when a 500 mb trough extends southward to 35 N and:

(1) The distance of the trough axis (degrees longitude from Gibraltar), when plotted against the 500 mb height at Gibraltar, lies within the shaded area in Figure I-11.

(2) Surface pressure at Gibraltar is either below the monthly average shown in Table I-7, or average and falling.

Points falling in the central, darkly-shaded area of Figure I-11 indicate that thunderstorms are likely at Gibraltar.

Table I-7. Mean monthly surface pressure at Gibraltar (station 08495).

MONTH	JAN	FEB	MAR	APR	OCT	NOV	DEC
Pressure (mb)	1020	1020	1019	1016	1017	[illegible]	[illegible]

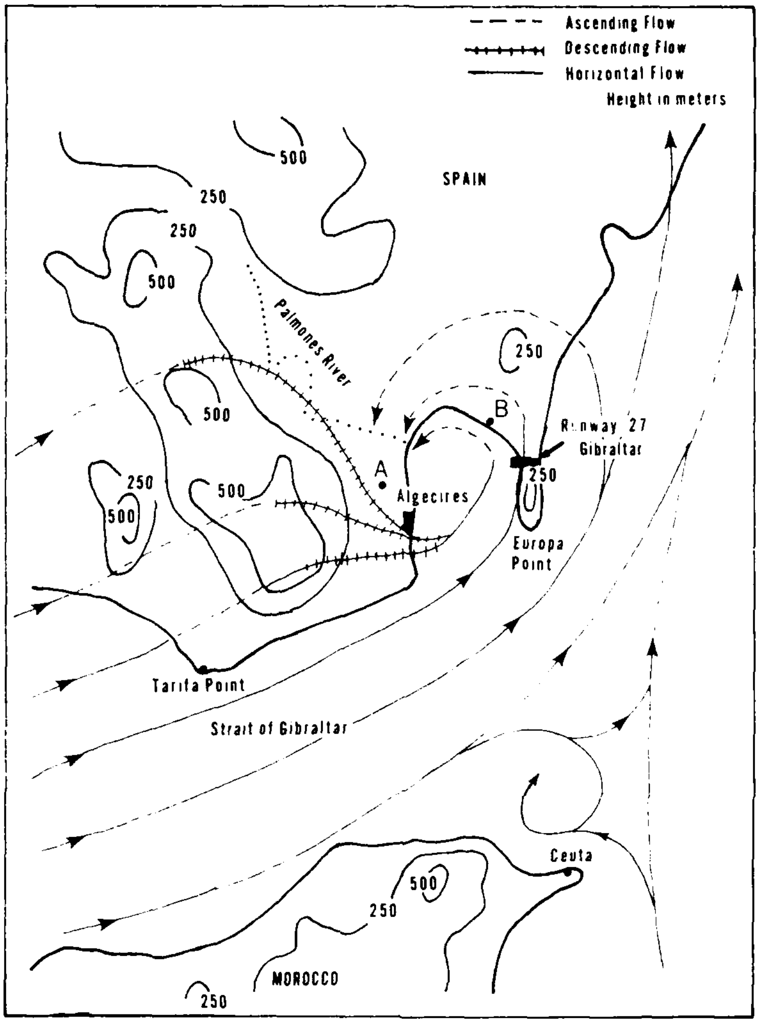


Figure I-10. Sea-breeze circulation in the vicinity of Gibraltar for case with 2000 ft winds from the west. "A" is a smoke source (factory) and "B" is an oil refinery.

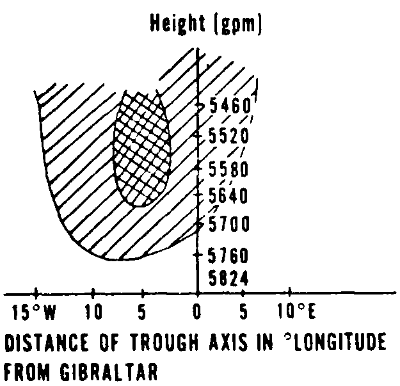


Figure I-11. Diagram used to forecast rain/no rain and thundershowers as a function of 500 mb height at Gibraltar (station 08495) and distance of 500 mb trough axis (extending to 35°N) from Gibraltar. Shaded area, forecast rain and for hatched area, forecast thundershowers.

66. If a 500 mb closed vortex is located in the area shown in Figure I-12:

(1) Forecast no rain at Gibraltar if the 500 mb height at the station is between 5580-5690 meters and surface pressure is either below the monthly average shown in Table I-7, or average and falling.

(2) Forecast rain at Gibraltar if the 500 mb height at the station is less than 5580 meters.

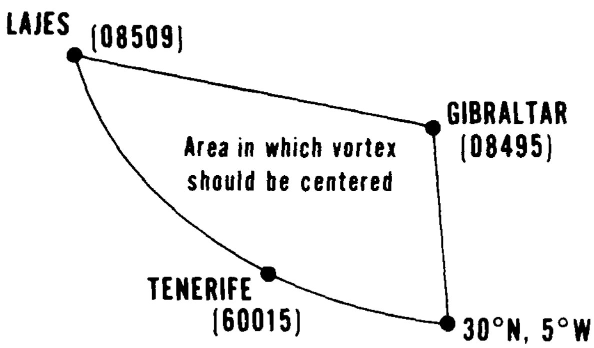


Figure I-12. Diagram showing area in which 500 mb vortex must be located for rain forecast at Gibraltar (station 08495).

67. If Gibraltar is located in the region of a 500 mb ridge:

(1) Forecast rain at Gibraltar ahead of a warm front approaching from the west if the 500 mb ridge has little amplitude.

(2) Forecast rain at Gibraltar if ridge is in a warm sector with an active cold front south of a line Lisbon-to-Madrid.

(3) Forecast no rain at Gibraltar if the 500 mb ridge is in a warm sector and all fronts are north of a line Lisbon-to-Madrid.

(4) Forecast no rain at Gibraltar if the ridge is obviously not frontal and weather is anticyclonic.

68. If the airstream flowing over Gibraltar is unstable:

(1) Forecast rain if the 500 mb flow is strong and directed toward Gibraltar from the northwest while showing evidence of troughing; and if the surface pressure at Gibraltar is either below the monthly average in Table I-7, or average and falling.

(2) Forecast showers if a fresh or strong surface easterly airstream directed toward Gibraltar has a trajectory which veers so as to increase its over-water track.

(3) Forecast continuous rain if condition (2) is met, and if the lift caused by local convergence in the Strait of Gibraltar is expected to push cloud tops above the 0°C isotherm.

(4) Forecast showers if an upper level vortex is located over Spain and sufficient moisture exists to cause cumulus development.

69. In the Gibraltar area, forecast precipitation to end when the upper winds above 5000 ft veer to north of west.

70. This rule provides guidance for forecasting surface wind at Gibraltar for light wind situations. If the Alicante/Casablanca pressure difference is less than 3 mb, the surface wind speed will be 10 kt or less. The only exceptions are possible sea breezes which may reach 15 kt.

(1) Easterlies. Forecast winds to become easterly in about 12 hours if the surface pressure is higher at Alicante than at Oran. However, if pressure at Casablanca is rising rapidly, easterly winds will not materialize. If easterly winds are forecast to arrive during the night, winds will not become easterly until an hour or so after dawn. Direction at onset is 070°. During winter, wind remains from this direction; in summer (May-September), however, it veers to 110° by day. Maximum speeds of these easterlies occur around mid-afternoon.

(2) Westerlies. Onset is heralded by changes in pressure distribution, with pressure becoming lower at Alicante than at Oran. Westerly wind flow normally begins at night. If a change in pressure distribution occurs during the morning, expect westerlies to begin aloft (2000 ft), leading to sea breeze from 200° by midday (up to 15 kt), and veering to westerly about 1900-2000 GMT (onset of katabatic wind at Gibraltar).

71. This rule provides guidance for forecasting surface wind at Gibraltar for moderate wind situations. If the Alicante/Casablanca pressure difference is between 3 and 5 mb, the surface wind speed will be 8-15 kt with possible gusts to 25 kt.

(1) Easterlies. Weak cold fronts moving southwestward in association with a mistral in the Gulf of Lion will cause a rapid onset. If a katabatic wind continues during the night, easterlies can be expected immediately after dawn. If the pressure change is rapid, a sudden onset of wind is likely. The direction of easterlies is 070° at night, veering during the day to 090° in winter and 110° in summer. Maximum speeds occur in the afternoon.

(2) Westerlies. Westerlies are rather variable in both speed and direction. During the summer, a sea breeze is frequent with direction from 200° and speeds up to 15-20 kt in the afternoon. A katabatic wind at night causes a secondary but weaker maximum. If the temperature inversion's top is below surrounding hills, the katabatic direction will be from south to west. If the air mass is unstable, the katabatic direction will be near the 2000 ft wind direction.

72. This rule provides guidance for forecasting surface wind at Gibraltar for fresh or strong wind situations. The Alicante/Casablanca pressure difference produces the following winds:

Pressure Difference	Easterlies	Westerlies
5-10 mb	15-25 kt	15-20 kt
10-15 mb	25-30 kt	20-30 kt
greater than 15 mb	30-40 kt	greater than 30 kt

Onset is immediately behind a front. Easterly winds are usually preceded by a strong mistral in the Gulf of Lion 24 hours before flowing into the region of slack pressure gradient east of Spain. Directions are usually backed about 20° from the local gradient wind at Gibraltar. Sea breeze effects only occur if the 2000 ft wind is less than 20 kt. There are no katabatic effects.

73. This rule provides guidance for forecasting surface wind at Gibraltar for light and variable wind situations. With the Alicante/Casablanca pressure gradient at 1 mb or less, winds nearly always are light and variable, and sea breezes hardly ever occur.

74. Expect strong southwesterly winds at Gibraltar ahead of active cold fronts approaching from the west.

75. Strongest winds from a westerly direction at Gibraltar occur in the warm sectors of cyclones crossing southern and central Spain. Winds in the warm sectors are from the southwest and are enhanced by a marked isallobaric component due to rapidly falling pressures.

76. If depressions southwest of Portugal move northward up the coast, gale force southwest winds following warm frontal passages are not likely at Gibraltar.

77. A good indicator of the start of southwesterly gales at Gibraltar in association with an advancing cold front is the increasing of winds at Sevilla.

78. During the summer, fog at Gibraltar is heaviest around dawn (though it may occur at any time). Fog is most likely to occur with developing easterly flow after air has stagnated for a time in the Alboran Channel.

79. Conditions for fog formation in the Gibraltar area appear to be most favorable when surface winds shift from westerly to easterly after an extended period of westerlies. The fog can be expected to appear less than 18 hours after the shift.

80. Fog occurs least in the Gibraltar area during the period October through April. It is most likely during these months when sea surface temperatures are below normal.

81. In summer, westerly winds at Gibraltar are normally associated with fair and clear weather, while light easterly winds are associated with low stratus and fog patches.

82. Clear weather is expected at Gibraltar during periods of cold, unstable, northerly flow over Spain even though bad weather will be observed to the east and west of the station. This good weather is caused by the shadowing effect of mountains.

RULES FOR PORTS AND ANCHORAGES, BARCELONA, RULES 83-85

83. During mistral conditions in the Gulf of Lion, there is a northeasterly swell present at the carrier anchorage at Barcelona. With a 40 kt mistral, the swell at Barcelona is approximately 4 ft.

84. The carrier anchorage at Barcelona is exposed to high seas from the east and northeast. These conditions generally occur during the winter when a depression is located in the sea area east of Barcelona and west of Corsica and Sardinia. A low northeasterly swell is an indication of possible high winds and seas associated with these depressions. (This swell may also be caused by a mistral; see Rule 83).

85. It is a rule of thumb at Barcelona that anytime there is a northeasterly swell in Barcelona in the afternoon, boating will be cancelled the next day and for at least the next three days.

RULES FOR PORTS AND ANCHORAGES, PALMA, RULE 86

86. At the carrier anchorage at Palma, sustained south to southwesterly winds of 20 kt or greater cause boating difficulties. Brief periods of 20 kt southwesterly winds can cause 5 ft seas.

RULES FOR PORTS AND ANCHORAGES, TANGIER, RULE 87

87. If the gradient level winds at Tangier are north of 090°, there will be no low-level turbulence. However, if the gradient wind veers to the south of 090° (about 130-140°), strong low-level turbulence will occur both at the airfield and over Tangier Bay. Over the bay, gusts up to 60 kt at the surface occur when mean wind speeds of 25-30 kt are present.

RULES FOR PORTS AND ANCHORAGES, VALENCIA, RULES 88, 89

88. Strong and gusty northwesterly winds are common at Valencia due to funnelling through mountain valleys.

89. Strong southwesterly to westerly winds (230° to 280°) are common at Valencia. The synoptic situation producing these winds is characterized by a high that lies south of the Azores, tries to build northward, and is prevented from doing so by deep lows in the Atlantic which approach the British Isles and the coast of Europe. Maximum wind speeds at Valencia during these situations occur from 0900 LT to 1200 LT and/or 1400 LT to 1500 LT. Minimum wind speeds occur from 1600 LT to 0000 LT.

II. GULF OF LION – WEST CENTRAL MEDITERRANEAN AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Gulf of Lion-West Central Mediterranean Area* shown in Figure II-1 encompasses the Gulf of Lion, western Ligurian Sea, and that part of the Mediterranean Sea between the Balearic Islands to the west and the islands of Sardinia and Corsica to the east. For purposes of this discussion, the Strait of Bonifacio is included both in this area and in the Tyrrhenian Sea-Central Mediterranean Area addressed in Section III.

A complex coastal topography characterizes the north and the south coasts of this area (see Figure II-1). There are three major mountain barriers to the north -- the Pyrenees, the Massif Central, and the Alps -- and three major valley openings to the sea -- the Carcassonne Gap, the Rhone Valley and the Durance Valley. Such topographical features frequently combine to create channeling of the air flow in the valleys, prominent corner effects, and/or obstacle effects to air flow over the mountain barriers.

Along the southern coastal boundary area, the Atlas Mountains are dominant with the Tellien Atlas to the west and Massif De L'Aures to the east. The Bishra Gap between these latter two ranges can promote strong channeling of the air flow.

1.2 SEASONAL WEATHER

The seasonal weather patterns of the Gulf of Lion-West Central Mediterranean Area are dominated by the major influxes of cold air into the Mediterranean that usually occur along the northern boundary of the area, creating the cold outbreaks with associated northwesterlies known as mistrals (see Para. 2.1).

During the winter season (November through February), when the upper-level westerlies and associated storm track are positioned over the area, unsettled and stormy weather, alternating with strong to gale force mistrals, is common. During the summer season (June through September), when the upper-level westerlies and associated storm track retreat to the north, settled and warm, dry weather is much more the rule. However, mistral conditions associated with cold outbreaks are still common near the coast of southern France.

*Comprises British forecast sea areas Lions, Unicorn, Bougie; see Figure 1b in the Introduction.

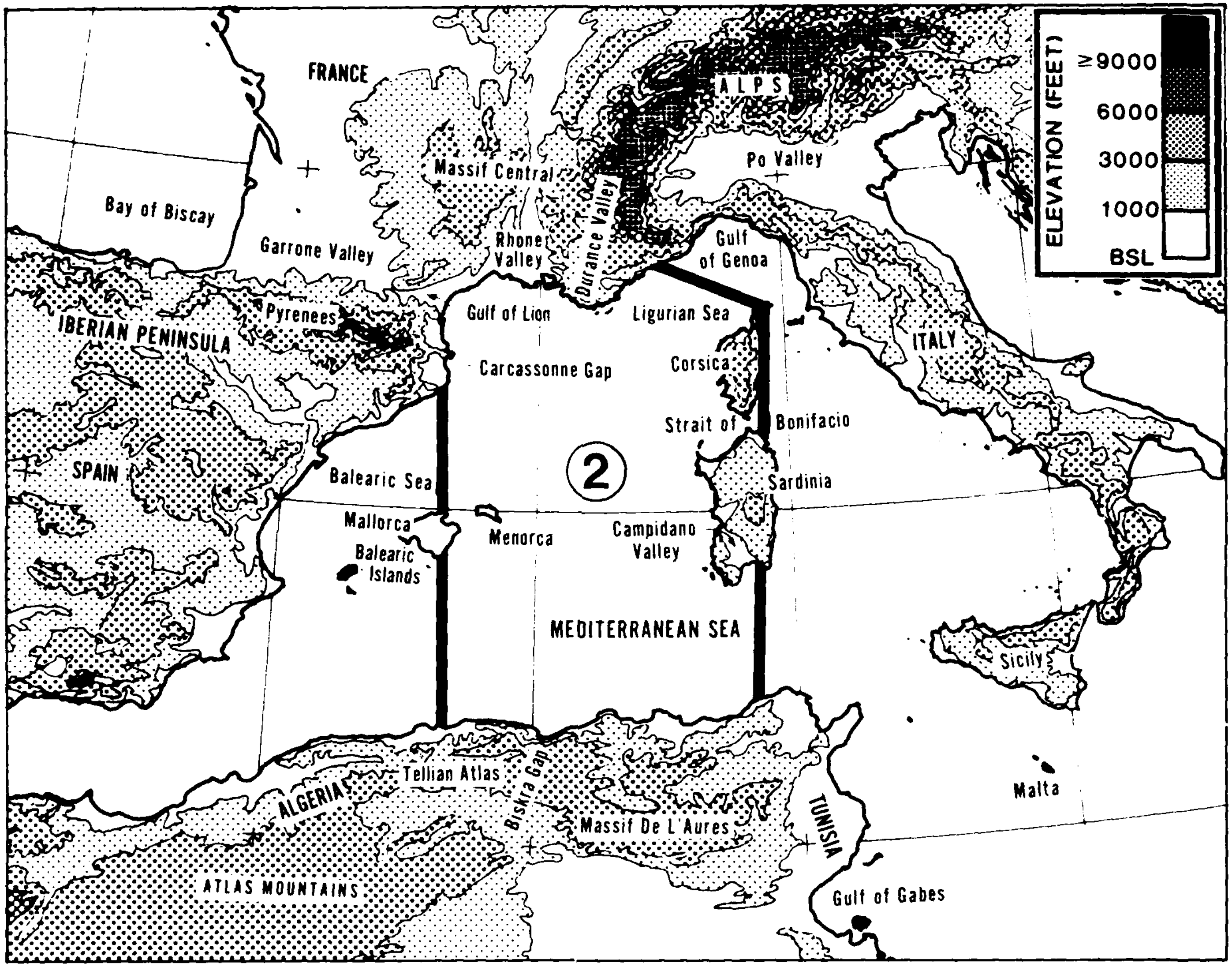


Figure II-1. Topographical map of Gulf of Lion - West Central Mediterranean Area.

The transitional seasons, spring and autumn, are of very different length. The relatively long spring season (March through September) is noted for periods of stormy weather with mistral conditions that alternate with a number of false starts of settled summer-type weather. Autumn lasts only about one month (October), and is characterized by an abrupt change to winter-type weather.

2. REGIONAL WEATHER PHENOMENA

2.1 MISTRAL

2.1.1 Introduction

The mistral is a cold, strong northwesterly to north-northeasterly offshore wind along part or all of the coast of the Gulf of Lion. Its influence occasionally extends beyond the Gulf of Lion to affect the weather of the entire Mediterranean basin.

The mistral is the result of a combination of the following factors:

(1) The basic circulation that creates a pressure gradient from west to east along the coast of southern France. This pressure gradient is normally associated with Genoa cyclogenesis.

(2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the southern coast of France and thus increasing the wind speed.

(3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassone Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia.

(4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).

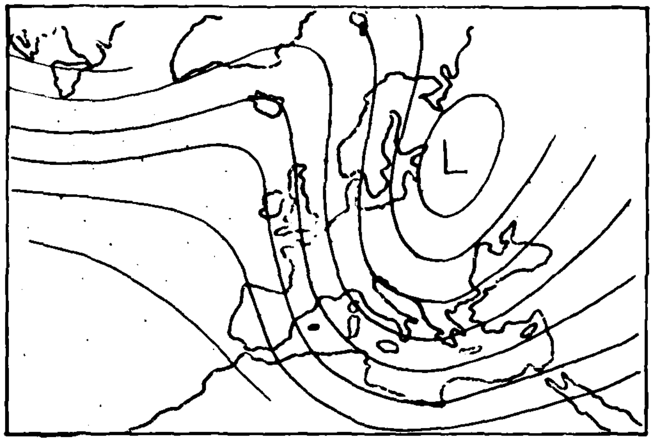
Mistrals are observed in association with three particular upper level (500 mb) large-scale flow patterns. These flow patterns are classified as types A, B, and C (British Air Ministry, 1962; see Introduction).

Type A. A blocking ridge in the eastern Atlantic and a long-wave trough over Europe produces a strong northwesterly flow over western France (see Figure II-2). This is a meridional flow situation.

Type B. A blocking ridge extends northeastward from the eastern Atlantic over northern Europe and a low pressure belt covers the Mediterranean (see Figure II-3). Meridional flow predominates.

Type C. A series of depressions dominates the European mid-latitudes, and westerly winds prevail over the Mediterranean (see Figure II-4). This is a zonal-flow situation.

Figure II-2. Upper-level flow pattern showing the British Air Ministry Type A.



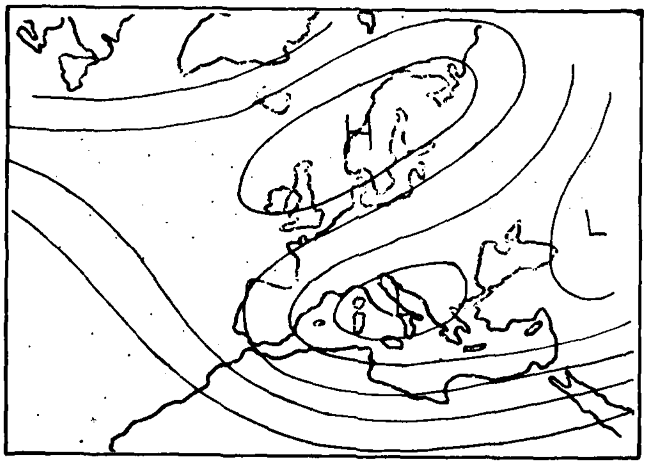
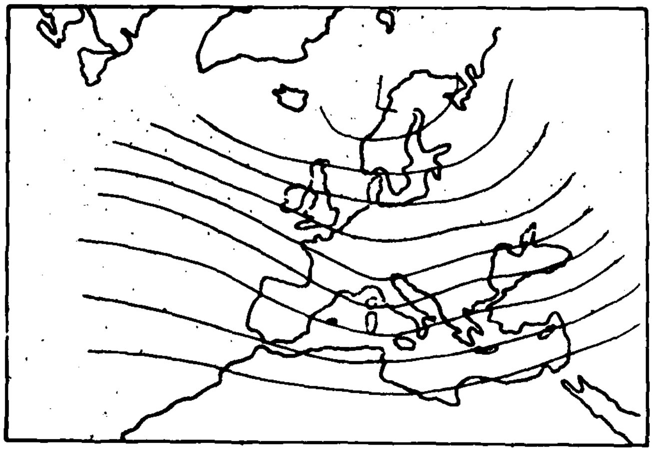


Figure II-3. Upper-level flow pattern showing the British Air Ministry Type B.

Figure II-4. Upper-level flow pattern showing the British Air Ministry Type C.



It should be noted by users of the British Air Ministry classification system that the three types often merge from one to the other or form combinations which can make classification extremely difficult.

2.1.2 Climatological Properties

Strength. Mistral wind speeds often exceed 40 kt and occasionally have reached 100 kt in gusts along the coastal region from Marseille to Toulon. Over the open water in the Gulf of Lion, at the French buoy TOQD (see Figure II-9 for location), mistral wind speeds locally greater than 40 kt occurred in nearly 8% of total observations.

Direction. Wind direction along the shore is primarily a function of the orientation of the valleys. Over the open water in the Gulf of Lion, the predominant direction is 320°-340° (data from French buoy TOQD).

Horizontal Extent. The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing southeastward. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as North Africa, Sicily and Malta, as well as very strong westerly winds in the Bonifacio Strait.

The lateral extent of the mistral over the sea is related to the sheltering effect of the Pyrenees and Alps. Sharp shear lines between the high and low wind speeds are found downstream from the edges of these mountain chains. The boundary from the northeast corner of Spain to Menorca is usually well marked.

Seasonal and Diurnal Variation. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring. Figure II-5, for example, shows that at Marignane the greatest number of mistrals of 30 kt or greater occur during the months of February through April.

The diurnal variation in the intensity of the mistral appears quite different between coastal stations and observations over the open sea. At coastal stations the maximum mistral winds tend to occur in the afternoon, while over the sea (data from French buoy TOQD) they tend to occur during the night, as shown in Figure II-6.

Sea Conditions. Seas increase rapidly with the onset of mistral conditions. Significant sea heights of up to 24 ft have been reported during storm force mistral conditions in the Gulf of Lion (data from French buoy TOQD); significant sea heights of up to 30 ft can be expected farther from the coast. More typical values of sea heights are 15-20 ft.

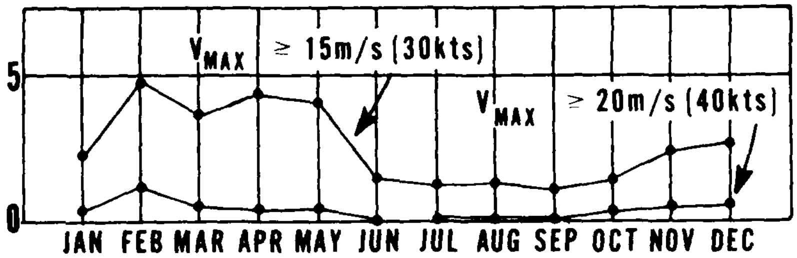


Figure II-5. Mean monthly frequency of mistrals at Marignane (1957-1966) for different threshold values of wind speed.

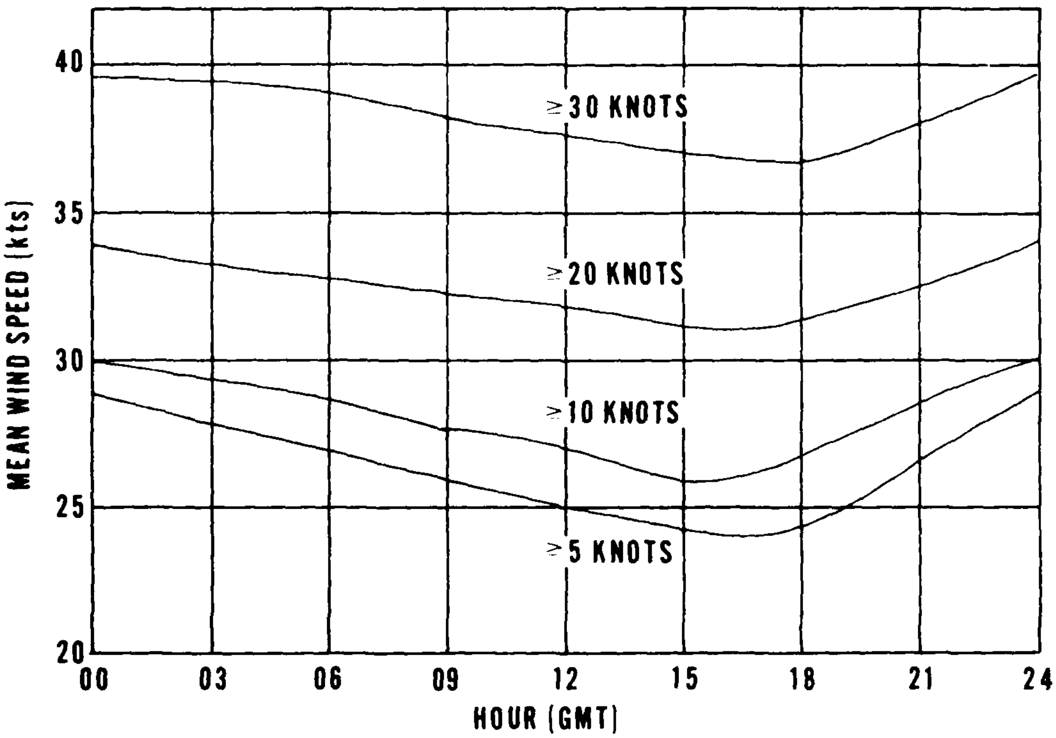


Figure II-6. Diurnal variation of mean mistral winds beyond indicated speed thresholds at TOQD.

Clouds and Weather. The mistral is a katabatic wind, characterized by the sinking and spreading of cold air. Skies along the coast are usually clear. Precipitation is uncommon, except when the mistral is shallow with a southerly flow of mid-levels that causes middle cloudiness and rain. Other exceptions are at the cold front associated with the onset of the mistral and at secondary cold fronts associated with reintensification of mistral conditions. However, as the cold air moves out over the warmer water, convective cloudiness does increase. (See Figure II-7 for a typical case.) Very poor atmospheric visibilities also have been reported up to a height of 30 m during cases of extremely strong mistrals because of a layer of spray that extends above the water surface.

2.2 SIROCCO

The sirocco is a southeasterly to southwesterly wind over the Mediterranean originating over North Africa. Because the air's source regions are deserts, the sirocco is extremely dry at its source, warm in winter, and hot in spring and summer. Its influence occasionally extends over the entire Mediterranean basin, but it is most pronounced in the Gulf of Gabes east of the Atlas Mountains.

In the Gulf of Lion-West Central Mediterranean Area, the sirocco usually occurs in the warm sector of cyclones moving across the area. In the vicinity of the Gulf of Lion, the sirocco is known as the "marin." The direction of the marin is southeasterly, the reverse direction of the mistral in the Gulf of Lion. Over the Ligurian Sea the direction is southerly, but at times gale force easterlies also are associated with the sirocco.

Sirocco weather can vary from severe dust storms to heavy fog and rain. Skies normally can be expected to be relatively clear along the north coast of Africa, but visibilities will be reduced because of dust/sand picked up by the winds from the desert regions to the south. To the north, low stratus and fog occur as the air picks up moisture in the lowest levels from the relatively cool water surface. Given the volumes of dust in the air, visibilities in these situations can be very low.

2.3 CYCLONE OCCURRENCES

Cyclones affecting the Gulf of Lion-West Central Mediterranean Area usually originate in three regions (see Figure II-8):

(1) North Africa, south of the Atlas Mountains (North African cyclones).

(2) Gulf of Genoa, Ligurian Sea, Po Valley and, in a broader sense, south of the Alps (Genoa cyclones).

(3) Balearic Sea, off the east coast of Spain

Figure II-7. DMSP high-resolution visual image, 1122 GMT, 28 January 1973.

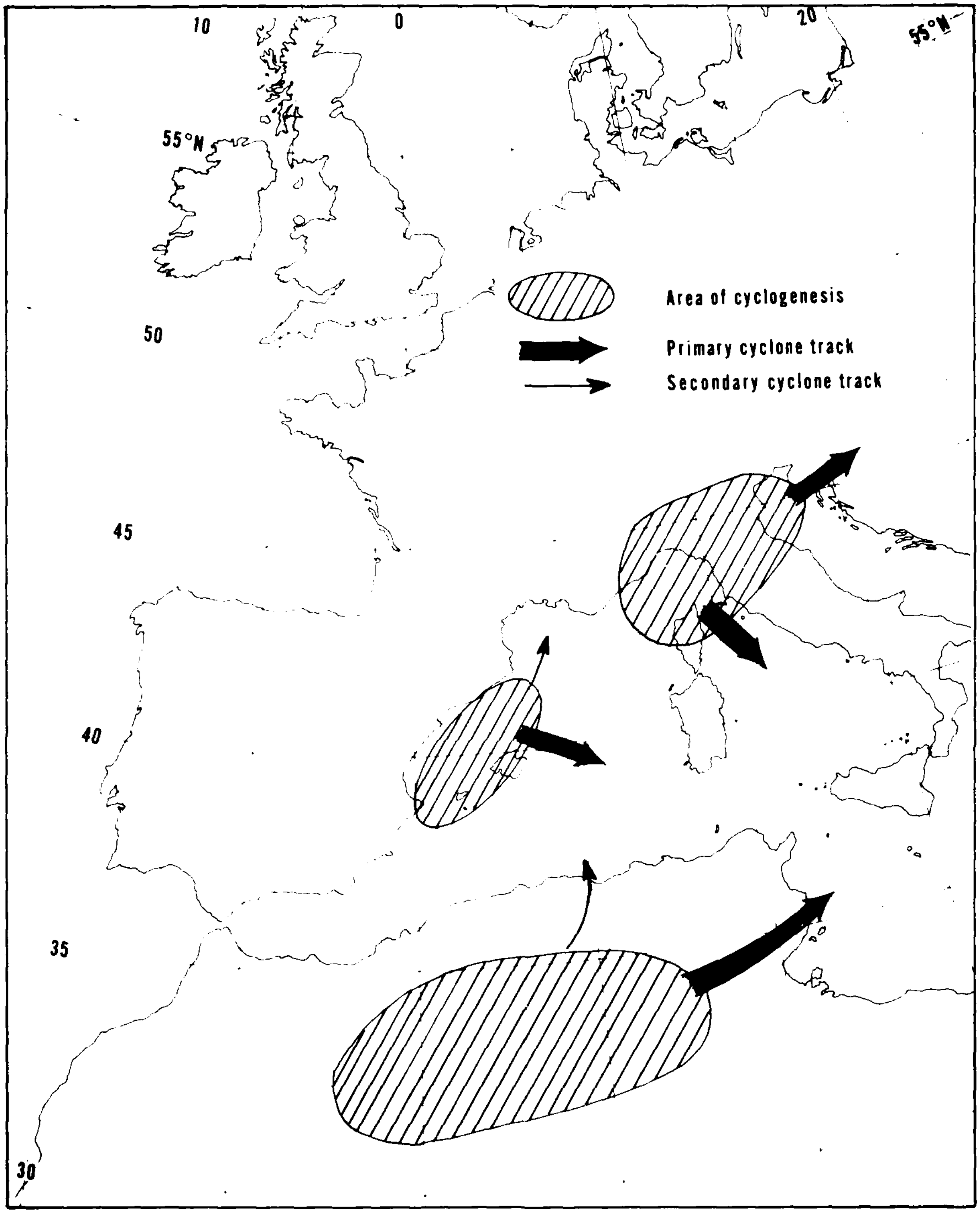


Figure II-8. Areas of cyclogenesis and tracks of cyclones which affect the Gulf of Lion - West Central Mediterranean Area.

The North African cyclone (of the type described in detail in Section V, Para. 2.5.1) is most common during the winter and spring. It generally moves eastward south of the Atlas Mountains, recurving northeastward over the Mediterranean only after reaching the Gulf of Gabes. It is only when the cyclone moves northward across the Atlas Mountains (a rare event) that it directly affects this area. During cases of strong upper-level southwesterlies across the Atlas, however, lee cyclogenesis does occur over the water. These secondary systems can be quite intense, but usually decay as soon as the parent low moves off to the east.

The Genoa cyclone (of the type described in Section III, Para. 2.3.1) affects weather conditions in this area although it generally develops and remains in the east. Its major effect is the intensification of the east-west pressure gradient and thus the strength and extent of the mistral wind regime.

Cyclogenesis off the east coast of Spain is of major importance in the Gulf of Lion-West Central Mediterranean Area during winter. These cyclones usually develop as secondaries to cyclones moving eastward across the Iberian Peninsula and appear to develop in a lee trough over the Balearic Sea. Although they generally move southeastward across the area, at times they drift northward over the Gulf of Lion.

3. FORECASTING RULES

Tables II-1 through II-4 provide quick reference to the 68 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location within the area of interest. Observing stations locations are shown in Figure II-9, and listed in Table II-5.

Table II-1. Forecasting rules for the mistral.

Onset	48 hr lead time	Rules 1,2
	24 hr lead time	Rules 3-5
	Unspecified lead time	Rules 6-12
	Lead time dependent on other factors*	Rules 13-19
	≤6 hr lead time	Rules 20-23
Intensity	General	Rules 24-27
	Gulf of Lion	Rules 28-32
Horizontal Extent		Rules 33-36
Cessation		Rules 37-39
Other		Rules 40,41

*The Fleet Numerical Oceanography Center (FNOC) prog package can be expected to give useful information concerning the occurrence or nonoccurrence of mistral conditions. The best results are seen when the FNOC 500 mb analysis accurately depicts the sharpness of approaching short wave troughs along with positions and extent of the polar jet. These conditions can be checked by comparing the FNOC analysis with wind, height and temperature data from the radiosonde stations at Bordeaux, Brest, Valentia, Camborne, and Long Kesh.

Table II-2. Forecasting rules for cyclonic activity.

North African	Secondary development	Rule 42
	Maximum wind	Rules 43, 44
	Movement	Rule 45
Other		Rules 46-48

Table II-3. Other forecasting rules.

Frontal Movement/Placement	Rules 49,50
Channeling	Rules 51,52
Low-Level Jet	Rule 53
Southwesterly Gales	Rule 54
Station Reports	Rule 55
Fog	Rule 56
Haze	Rules 57-59

Table II-4. Forecasting rules for ports and anchorages.

Villefranche, Beaulieu, Monaco, Cannes	Rules 60-67
Marseille	Rule 68

Table II-5. List of observing stations.

Name of Station	Block No.	Index No.
	(Lat., Long.)	
Beaulieu	43°43'N 7°18'E	
Bordeaux	07	510
Bougie	60	402
Brest	07	110
Camborne	03	808
Cannes	07	684
Capo Della Frasca	16	539
Istres	07	647
Long Kesh	03	920
Lus La Cruix Haute	07	587
Mahon	08	314
Marseille/Marignane	07	650
Monte Carlo	43°44'N 7°25'E	
Montpellier	07	643
Nice	07	690
Nimes	07	646
Orange	07	579
Palma	08	302
Perpignan	07	747
Sanremo	43°48'N 7°46'E	
TOQD	42°13'N 5°34'E	
Toulon	07	660
Valentia	03	953
Villefranche	43°42'N 7°18'E	

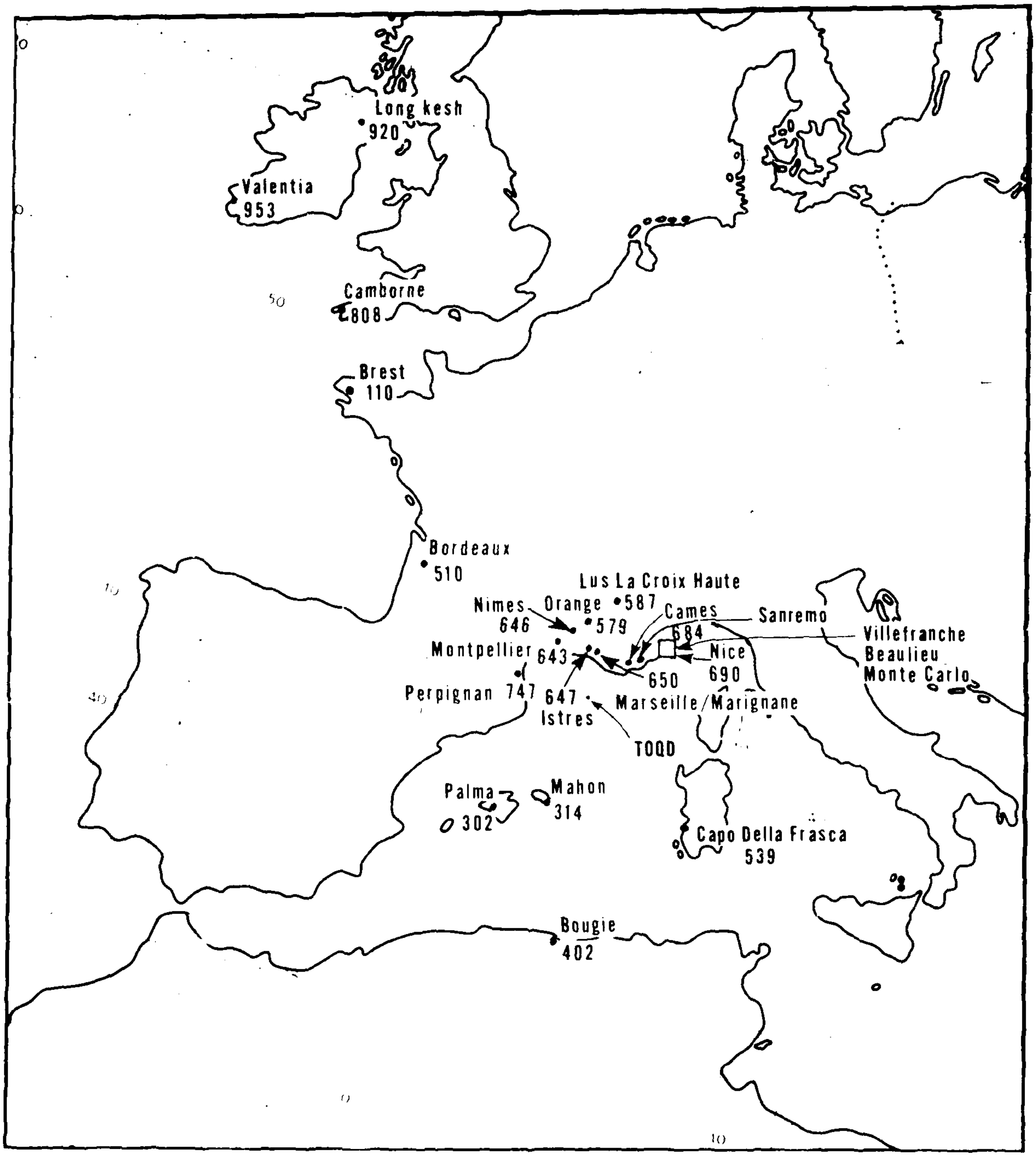


Figure II-9. Station locator map for the Gulf of Lion - West Central Mediterranean Area.

MISTRAL, ONSET, RULES 1-23

1. In association with a Type A* large-scale flow pattern as shown in Figure II-2, forecast the start of a mistral within 48 hr when a surface frontal trough is located just south of Iceland and is backed by an extremely strong surge of cold air to the east of Greenland. (Note: The longwave ridge axis is west of Iceland; this rule is biased toward established rather than developing patterns.)

2. In association with a Type C large-scale flow pattern as shown in Figure II-4, forecast the start of a mistral within 48 hr when (1) a surface frontal trough and upper short-wave trough are 24° of longitude to the west of the Gulf of Lion, (2) the short-wave ridge is 12° west, and (3) both are progressing at a speed of 12° per day. (Note: The "rule of thumb" in this case is that these short-wave ridges and troughs replace each other in 24 hr, i.e., there is a tendency toward a 48 hr periodicity of frontal systems moving into France as long as the high-index circulation is maintained. Mistrals in this situation must be short-lived.

3. In association with a Type A large-scale flow pattern (Figure II-2), forecast the start of a mistral within 24 hr when the frontal and 500 mb short-wave troughs extend across southern (or southeastern) England and the Bay of Biscay, and the short-wave ridge is located over Spain and France. (Note: The long-wave ridge axis is west of Iceland. This rule is biased toward established rather than developing patterns.)

4. In association with a Type C large-scale flow pattern (Figure II-4), forecast the start of a mistral within 24 hr when the surface and 500 mb short-wave troughs extend from the Irish Sea southward over Portugal, and the short-wave ridge is over southern France. (Note: This pattern is poorly defined in this high-index situation.)

5. In association with a Type B large-scale flow pattern as shown in Figure II-3, forecast the start of a mistral within 24 hr when: (1) the 500 mb trough moves over or just south of the south coast of France; and (2) the associated surface low appears in or near the Gulf of Genoa.

6. The probability of mistral occurrence is greatest (correlation coefficient, r = 0.62) if the 500 mb wind direction at Bordeaux is 330°-340° or 040°-050°, when the 500 mb trough reaches Nimes. The probability decreases rapidly as direction changes either to the west or east from the 330°-050° band.

---

*Mistral types A, B and C (British Air Ministry classifications) are defined in Para. 2.1.1.

7. The probability of mistral occurrence with a blocking pattern is greatest (r = 0.30) if, at the time the trough reaches Nimes, the Nimes height deviation from normal is about +200 m. For progressive systems, the probability increases from r = 0.26 for deviations of +75 m to r = 0.98 for deviations of -350 m.

8. A mistral is likely to occur with a Type A situation (Figure II-2) when: (1) the long-wave trough is over or just past the south coast of France; and (2) a northwesterly (west through north-northeast) current with maximum speed of at least 50 kt at 500 mb is so oriented that it points toward the Gulf of Lion.

9. The probability of mistral occurrence is greatest (r = 0.58) when the 850 mb wind direction over Nimes is from 350°; it decreases with winds east or west of 350°, reaching near zero for winds from 240° and 090°.

10. The probability of mistral occurrence increases with the north component of the 850 mb wind at Nimes, reaching r = 0.93 for 50 kt.

11. In association with a Type A large-scale flow pattern (Figure II-2), a mistral will occur if the 500 mb winds over England or Ireland are northwesterly 50 kt or more.

12. If a cutoff low as seen at 500 mb forms over northeast France and produces a northwesterly flow at 500 mb over the south coast, a mistral may occur even though 500 mb wind speeds do not reach 50 kt and the jet axis is located far to the west and south.

13. A mistral generally sets in when the surface front or trough passes Perpignan, or the 500 mb trough passes Bordeaux. (Note: These two events are expected to occur nearly simultaneously.)

14. In association with a Type C large-scale flow pattern (Figure II-4), a mistral will occur if a deepening 500 mb trough moves over the south coast of France and is followed by a 500 mb ridge building at about the longitude of Ireland and Spain.

15. Genoa lows occur almost simultaneously with the onset of the mistral in the Gulf of Lion, and they invariably form when conditions are right for a mistral to occur. (See rules on forecasting Genoa cyclogenesis in Section III.)

16. In association with a Type A large-scale flow pattern (Figure II-2), a mistral will start when the 500 mb short-wave arrives over Perpignan.

17. In association with a Type C large-scale flow pattern (Figure II-4), a mistral will start when a northwesterly jet stream arrives over the Bay of Biscay.

18. If a 500 mb trough extends from Central Europe southward over North Africa, a surface low from Algeria may propagate northward, intensify in the Gulf of Genoa, and initiate a mistral (see rules on forecasting movement of North African lows in Section V.)

19. The mistral will start when one of three differences is achieved: Perpignan-Marignane, 3 mb; Marignane-Nice, 3 mb; or Perpignan-Nice, 6 mb. A difference usually occurs from 0 to 24 hr after a closed Genoa low appears, but it occasionally occurs earlier.

20. Wave clouds, such as observed on high-resolution Defense Meteorological Satellite Program (DMSP) satellite imagery, are observed over the Massif Central of Southern France approximately 6 hr before the start of a mistral (see Figure II-10).

21. Lus La Croix Haute will provide a 2-3 hr advance notice of mistral onset. This wind speed report will closely approximate the wind speed in the Gulf. (Note: Usefulness of this station limited by the fact it only reports every 3 hr.)

22. Orange gives a good 3-4 hr warning of a gale force mistral when winds at this station increase to 25 kt northwesterly. Hourly reports are available from this station.

23. By observing changes in the normally strong afternoon sea breeze (east-southeasterly direction) at Perpignan, it is possible to forecast the beginning of a mistral in the Gulf of Lion. If, at this station, the wind shifts northerly with speeds increasing to 25-30 kt and the temperature drops at least 3°F, a strong mistral (40-50 kt) will be blowing in the Gulf of Lion within 6 hr.

MISTRAL, INTENSITY, RULES 24-32

24. Strongest winds associated with a mistral do not occur until after the passage of the upper-level (500 mb) trough. This occurs well after the surface cold frontal passage.

25. Forecast mistral winds to increase during a Type A large-scale flow pattern (Figure II-2) in about 24 hr after a new cold front or minor trough appears in the northwest current over southern England, and the maximum speed at 500 mb in the current increases at least 10 kt while the inflection point (IP) retrogrades or remains stationary; or with the passage of the new cold front or minor trough.

26. Satellite observations indicating a strong mistral will exhibit the following features: cloudy over France and clear over the water area south of the 1000' water depth contour; clear over the Gulf of Lion but a cloud mass, parallel to the coast, lying 75-150 n mi offshore; wispy cloud streaks extending from 315° to 360° into offshore clouds (see Figure II-11).

Figure II-1[illegible]. DMSP high-resolution visual image, [illegible]

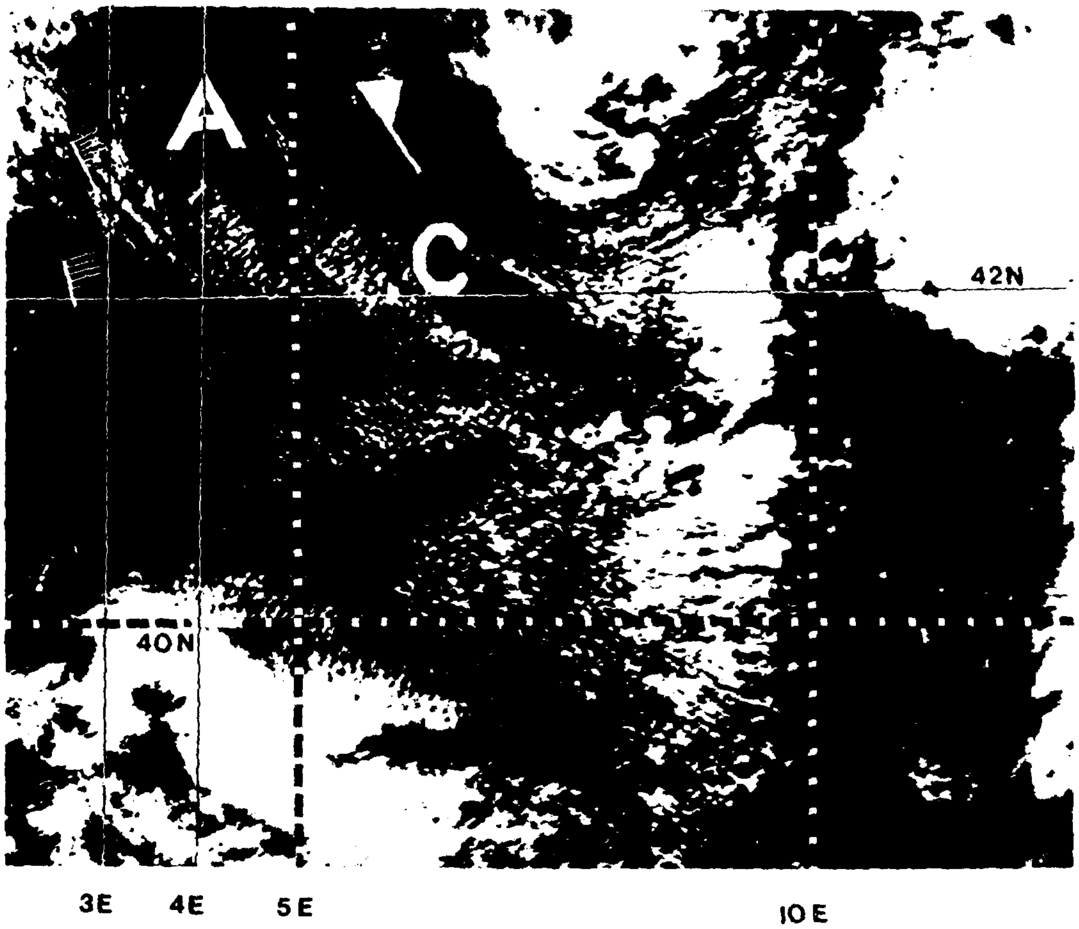


Figure II-11. DMSP satellite photo of storm force mistral winds in the Gulf of Lion and west Mediterranean during April 1975 verified by the four attendant 45 kt land and ship reports.

A. Shows typical clear coastal area with increasing cloudiness down wind.

B. Shows southwest flow north of Corsica typical of 80 of mistral situations.

C. Shows area of strongest winds with sharp definition indicated in cloud patterns.

27. Wave clouds extending from Sardinia to Tunisia, viewed on satellite imagery, are generally associated with gale force mistral situations [illegible] Figure II-7).

28. Use the table below to estimate wind speed associated with a mistral in the Gulf of Lion.

Pressure Difference* (mb)	Perpignan (station 07747) and Nice (station 07690)	Perpignan and Marignane (station 07650)	Marignane and Nice
3		30-35 kt	30-35 kt
4		40	40
5		45-50	45-50
6	30-35 kt		
8	40		
10	45-50		

*Highest pressure at Perpignan.

29. Wind speeds over open water during a mistral will be approximately double those measured at Perpignan or Marignane except in storm conditions, when the ratio will be lower.

30. A good indication of the intensity of a mistral in the Gulf of Lion can be obtained by adding 10 kt to the wind speed reported by either Montpellier or Istres.

31. If the 500 mb winds reported at either Bordeaux or Brest are northwesterly at 65 kt or greater, storm warnings instead of gale warnings are indicated for the Gulf of Lion.

32. Maximum mistral winds occur when the surface isobars are at an angle of 30° to the valleys of either the Garonne, the Rhone or the Durance with low pressure to the southeast.

MISTRAL, HORIZONTAL EXTENT, RULES 33-36

33. The eastern boundary of the mistral extends downwind from the western edge of the Alps through Sanremo.

34. The western boundary of the mistral has the following characteristics:

(1) The boundary is generally narrow, 2-20 n mi wide.

(2) Large changes in wind and sea conditions are observed across the boundary: winds generally are 8-16 kt to the west and 35-45 kt to the east of the boundary, while seas are 3-5 ft to the west and 14-20 ft to the east.

(3) The boundary defining the limit of the mistral appears to move generally from east to west especially in the region of the Balearic Islands. At times it oscillates from southwest Mallorca to northeast Menorca.

(4) The boundary occasionally is marked by a line of low clouds; at other times it is clear and can only be observed by the different effects of the wind on the surface of the sea.

(5) A relatively accurate location of the boundary is a line drawn to the North African coast through the stations at Perpignan, Mahon and Bougie.

35. The strong mistral winds which occur on the cyclonic side of and underneath the jet axis, will extend as far south or southeast as do the trough and jet stream.

36. Rule 35 applies primarily to Type A large-scale flow patterns (Figure II-2). If a deep trough extends to Sicily or Algeria, the mistral usually extends into the region of Sicily and Malta or, in extreme cases, to Algeria.

MISTRAL, CESSATION, RULES 37-39

37. In association with a Type A large-scale flow pattern (Figure II-2), surface winds usually decrease, i.e., the mistral ceases when the jet axis moves eastward and an anticyclonic regime is established. This rule reflects the control on the surface pattern that is exercised by the upper air pattern.

38. The mistral will cease when the cyclonic regime at the surface gives way to an anticyclonic regime. Indications of this change are:

(1) The surface wind direction becomes north to northeast.

(2) The 500 mb ridge begins to move over the area.

(3) High pressure at the surface begins to move into the western basin of the Mediterranean.

(4) There is a change that reduces the pressure difference between France and the western basin.

39. Cold advection on the western flank of a blocking ridge over the eastern Atlantic may herald the breakdown of the long-wave pattern and, hence of the mistral. This rule applies to Types A and B large-scale flow patterns where breakdown of the ridge, rather than eastward movement, results in cessation of the mistral.

MISTRAL, MISCELLANEOUS, RULES 40, 41

40. During strong mistral conditions in the Gulf of Lion, a strong diurnal wind variation in the sea area north of Mallorca has been observed, possibly the result of oscillation of the shear line described in Rule 34. Daytime wind speeds appear to be more than twice as strong as those at night; in one actual case, 10-20 kt daytime winds decreased to 4-6 kt at night.

41. Mistrals during late autumn and early winter may occur when air-sea temperature differences (water warmer than air) reach 6°C or more. At these times there is poor visibility in the lowest 30 m of the atmosphere because of a layer of spray. These mistral situations are also associated with damage to harbor installations along the Algerian and Tunisian coasts because of the unusually high sea and swell.

CYCLONIC ACTIVITY, NORTH AFRICAN, RULES 42-45

42. *A frequent development*, which occurs in conjunction with the appearance of a depression to the south of the Atlas range, is the generation of a low to the north of the Atlas range (Figure II-12). Such lows are usually formed when the upper flow over northwest Africa is between southwest and south; a lee effect is thought to be the initiating factor in this case.

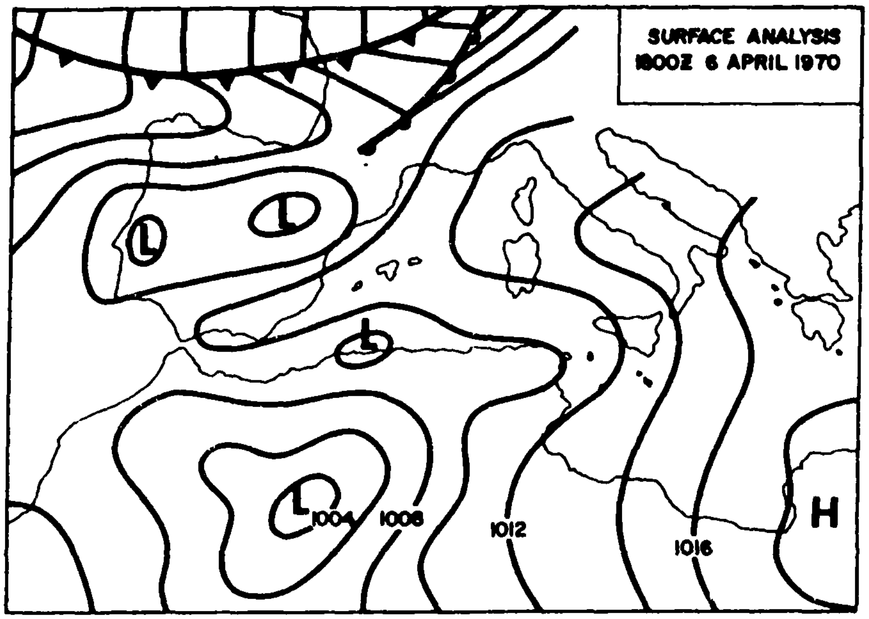


Figure II-12. Surface analysis, 1800 GMT 6 April 1970, example of a secondary depression north of the Atlas Mountains.

The two lows generally move eastward together, the parent to the south of the Atlas range and the subsidiary along the coast of Algeria and Tunisia. Should the upper flow over the Atlas back to southeasterly, the subsidiary low may remain stationary or even drift westward for a time. A close watch must be kept for the formation of the subsidiary lows; they are often small features that are difficult to see on a synoptic chart, but they can cause unexpected increases in wind and thundery outbreaks along the coast of Algeria and Tunisia. Occasionally they develop into major depressions, particularly on the arrival of a cold front from the north, and thereafter may move independently of the parent low.

43. Strongest winds associated with North African lows occur west of the centers when an incursion of cold air aloft arrives (seen at 500 mb).

44. It has been noted that the strongest winds associated with deepening North African lows, after moving out over the Mediterranean, occur in the northwest sector of the system rather than in the eastern sector.

45. Past numerical models sometimes have tended, incorrectly, to move developing North African lows northeastward across the Atlas Mountains. The actual course of these lows was usually first to the east, south of the Atlas Mountains, then northeastward after they reach the Gulf of Gabes.

CYCLONIC ACTIVITY, MISCELLANEOUS, RULES 46-48

46. Remnants of old cold fronts should be followed closely. In several cases cyclogenesis has originated along one of these fronts, even after cloudiness associated with these fronts had disappeared. This phenomenon has occurred when an upper level shortwave trough (SD minimum) approached from the west.

47. Cold fronts approaching the central Mediterranean become very active when they slow down. Multiple low centers with heavy rain are very common. This pattern remains stationary until the upper trough either moves eastward or fills.

48. Complex low pressure systems with multiple centers at the surface are a common event in the western Mediterranean basin. One center usually can be found in the Gulf of Genoa, and another over North Africa; a weak pressure gradient exists between the two systems. Which of those lows will develop depends greatly on the movement of an upper-level (500 mb) shortwave trough (SD minimum). If, for example, the SD minimum moves to the North African coast, the low center in that region will develop; this rapidly increases the pressure gradient, and causes easterly gales over the southern and central portions of the Mediterranean.

MISCELLANEOUS RULES, FRONTAL MOVEMENT, RULES 49, 50

49. Shallow cold fronts approaching the Mediterranean basin are greatly retarded by the mountain barriers. Deep cold fronts (those detectable at the 700 mb level) are not hindered by terrain features, and at times even accelerate. Movement of troughs at the 400 mb level appears to be useful in forecasting this acceleration.

50. Correct placement of fronts is very difficult in the western Mediterranean basin, particularly in summer when fronts are weakest, due to the lack of ship reports and to terrain effects. One of the worst such areas is over the Iberian Peninsula and Balearic Sea. Observers should be alert to the lee trough that develops along the east coast of Spain during periods of northwesterly flow: there is a tendency to designate this trough as frontal, instead of correctly moving the front eastward across the region.

MISCELLANEOUS RULES, CHANNELING EFFECTS LOW LEVEL JET, RULES 51, 52, 53

51. Winds with an east or west component are funneled through the Strait of Bonifacio in a "V" pattern. Rough seas are experienced within the "V", with wave heights often doubled on the eastern side of the Strait during mistral conditions.

52. High winds caused by channeling are observed in the Campidano Valley across Sardinia. With southeasterly winds normally associated with a sirocco, wind speeds at Capo Della Frasca, on the northwest end of the valley, can be triple those at nearby stations.

53. During periods of sirocco over the Mediterranean, there probably will be a low-level jet just below the top of the very marked temperature inversion common during sirocco conditions. Wind speeds reaching 70-80 kt, as well as heavy turbulence associated with strong vertical wind shear, have been observed in this jet.

MISCELLANEOUS RULES, SOUTHWESTERLY GALES, STATION REPORTS, FOG, HAZE, RULES 54-59

54. Strong southwesterly winds at 30-40 kt, associated with the early stages of lee cyclogenesis south of the Alps, are common in the region between the southern French coast and Corsica.

55. Some confusion has arisen in the past over the pressure tendency reported at Palma in the Balearic Islands. During the period from late winter through spring, large pressure falls of approximately 2 mb/3 hr at the 0300 GMT observation at Palma have been misleading. Apparently these pressure falls were a local effect, not indications of cyclogenesis. Mahon appeared to give more reliable information at these times.

56. Likely areas for the occurrence of fog during the summer are along the coasts of Corsica and Sardinia and between Sardinia and the North African coast.

57. Salt haze is a serious problem for flight operations over the Mediterranean. This haze has the following characteristics:

(1) It is most prevalent during the summer and early autumn.

(2) Its color is bluish white, as opposed to the brown of dust haze.

(3) Salt haze scatters and reflects light rays much more than does dust haze.

(4) Salt haze sometimes extends to over 12,000 ft and has been reported up to 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi, the slant visibilities for a pilot making a landing approach may be near zero, especially if the approach is in the general direction of the sun.

(6) It is sometimes thicker aloft than at the surface.

(7) It is less of a problem after sunset since the poor visibility is caused partially by scattering and reflection.

58. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing due to the presence of a strong ridge present at the surface and aloft.

59. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. Visibilities will improve, however, if there is an increase in the wind speeds at the 850 and/or 700 mb levels.

PORTS AND ANCHORAGES, SOUTHERN FRANCE, RULES 60-68

60. The carrier anchorage at Cannes is well protected from all but a southwesterly direction.

61. Cannes is not normally affected by the mistral, although white caps and rough seas can be observed just to the west of the harbor.

62. The most hazardous weather conditions at Cannes -- high winds, rough seas, thundershowers/storms and continuous rain -- are associated with depressions moving from the south towards the Gulf of Lion or the Ligurian Sea.

63. Depressions moving into the Ligurian Sea or across Corsica into Italy create a southerly swell (approximately 160° to 220° depending on the track) that enters the harbor at Cannes. This swell can be as high as 8-10 ft and persist for 2-3 days. The biggest problem with the swell is that the winds in the local area are usually from a different direction than the swell, which causes the swell to approach ships at anchor at critical angles of 45-90°.

64. Wind conditions at Cannes will vary considerably from those at Villefranche, Beaulieu and Monte Carlo.

65. The harbor at Villefranche is considered one of the safest in the Mediterranean. About the only time a mooring problem might arise is when a southerly swell enters the harbor (see Rule 63 for synoptic conditions producing a southerly swell). The swell can also cause an increase in water depth, raising the water level at the boat landing.

66. A strong pressure gradient in the vicinity of Villefranche and Beaulieu (high pressure to the north) will cause almost continuous high northerly winds at Beaulieu. At Villefranche, on the other hand, strong northerly winds of 20-40 kt will usually last only 1-2 hr.

67. Depressions forming in the Gulf of Genoa affect Monaco and Beaulieu with high winds, high seas, and occasionally severe thundershowers/storms. Since Villefranche is better protected from the east and northeast, the winds and seas there are much reduced.

68. During a mistral at Marseille there is a strong diurnal wind variation at the carrier anchorage; maximum winds occur in the afternoon and minimum winds are reached shortly after midnight. For example, wind speeds of 30-35 kt during the afternoon decrease to 20-25 kt at night.

With northwesterly winds in both the Gulf of Lion and the anchorage, westerly swell from the Gulf of Lion is experienced at the anchorage. Given a period of northwesterly winds at the anchorage of 25-35 kt, for example, a westerly swell of 4-5 ft and wind wave of 4-5 ft can occur. When the wind direction becomes more northerly in the Gulf of Lion, the swell diminishes. However, northwest winds of 35 kt gusting to 45-50 kt at the anchorage can produce wind waves of 6-8 ft even though the fetch to the northwest of the anchorage is only 3 n mi.

III. TYRRHENIAN SEA – CENTRAL MEDITERRANEAN AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Tyrrhenian Sea-Central Mediterranean Area* shown in Figure III-1 encompasses the Gulf of Genoa, the eastern Ligurian Sea, and the Tyrrhenian Sea southward to the north coast of Tunisia. Four important sea connections are also included:

(1) The Strait of Bonifacio between Sardinia and Corsica (see Section II).

(2) The Strait of Corsica between Corsica and the island of Elba.

(3) The Strait of Messina separating the mainland of Italy from Sicily (see Section V).

(4) The western end of the Strait of Sicily between Sicily and Tunisia (see Section V).

The major topographical features of the area are the Alps to the north and the Apennine mountains of Italy to the east. Although there are no major gaps in these mountain chains, there are numerous river valleys. The mountainous islands of Corsica, Sardinia and Sicily -- and the two major gaps, the Strait of Bonifacio and the Strait of Messina -- also affect weather in this area. The Alps are most important features insofar as they play a significant weather role in terms of planetary waves, cyclogenesis and fronts.

1.2 SEASONAL WEATHER

The seasonal weather patterns in the Tyrrhenian Sea-Central Mediterranean Area are dominated by the proximity of one of the most significant regions of cyclogenesis in the world, just to the south of the Alps in the vicinity of the Gulf of Genoa. (Genoa cyclogenesis is discussed in Para. 2.3.1 of this section.)

During the winter season, November through February, the upper-level westerlies and associated storm track are found over the area. Genoa cyclones with associated windy, unsettled weather are common. During the summer, June through September, however, the upper-level westerlies retreat northward; except for an occasional Genoa cyclone, settled, warm and dry weather with light winds is the rule.

---

*Comprises British forecast sea areas Genoa, Bonny, Volcano; see Figure [illegible] the Introduction.

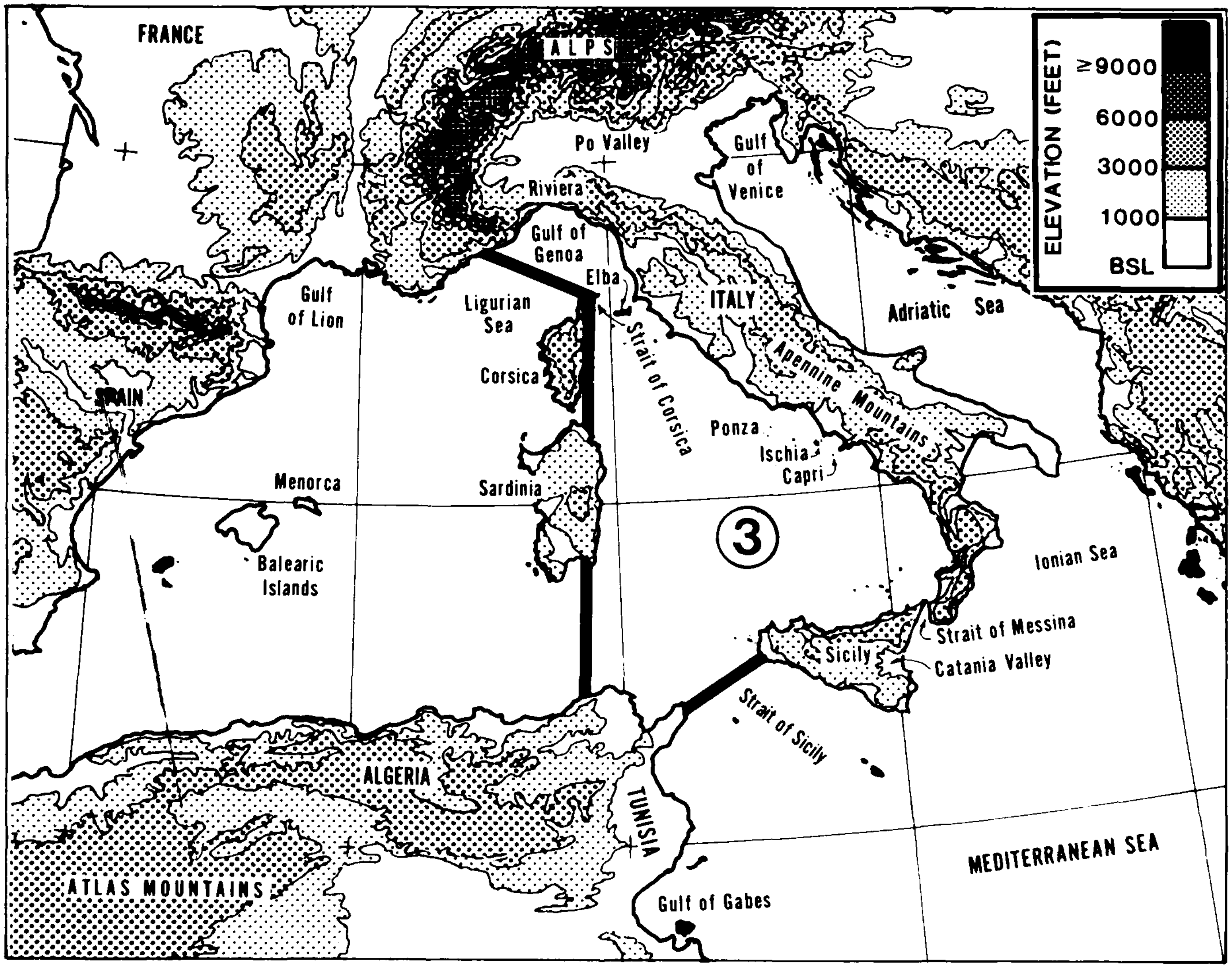


Figure III-1. Topographical map of Tyrrhenian Sea - Central Mediterranean Area.

The transitional seasons, spring and autumn, are of considerably different length. Spring, a relatively long period of March through May, is noted for periods of stormy winter-type weather associated with the continued high frequency of Genoa cyclones, alternating with a number of false starts of settled summer-type weather. Autumn, which usually lasts only for the month of October, is characterized by an abrupt change to winter-type weather.

2. REGIONAL WEATHER PHENOMENA

2.1 MISTRAL

The mistral (as described in Section II, Para. 2.1) is a cold, strong, northwesterly to north-northeasterly wind flowing offshore along the coast of the Gulf of Lion. Occasionally it extends beyond the Gulf of Lion, affecting not only the weather of the Tyrrhenian Sea-Central Mediterranean Area but also the entire Mediterranean Basin.

The extension of the mistral into the Tyrrhenian Sea-Central Mediterranean Area is closely related to both the upper-level large-scale flow pattern and the development and movement of the Genoa cyclone. The particular upper-level (500 mb) flow pattern associated with the southeastward extension of the mistral has a blocking ridge in the eastern Atlantic and a long-wave trough over Europe. A strong northwesterly jet associated with this flow pattern extends southeastward from western France (see Figure III-2).

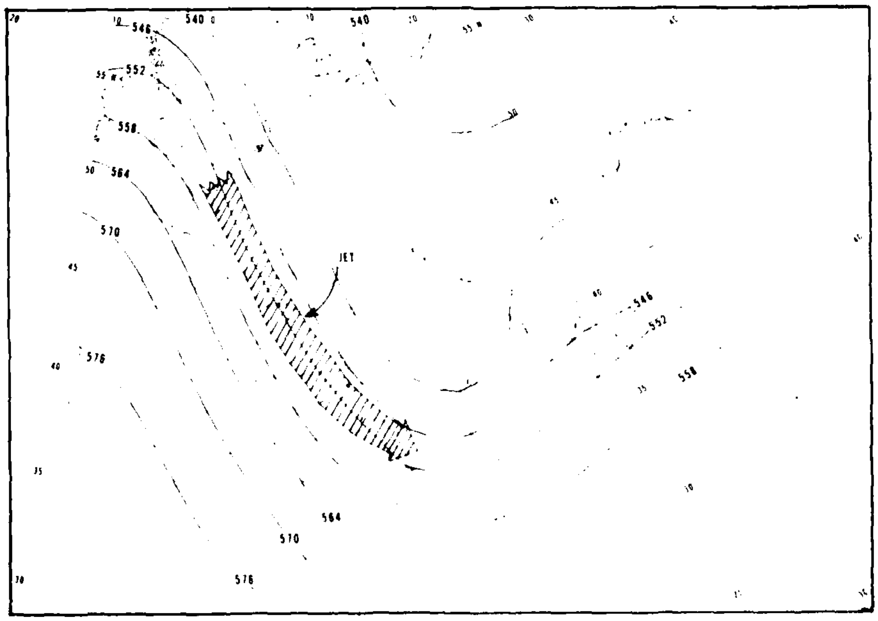


Figure III-2. 500 mb flow pattern showing extension of jet necessary for mistral conditions in the Tyrrhenian Sea - Central Mediterranean Area.

Although the mistral sometimes extends to the Strait of Sicily, much of the area is east of the strong mistral winds because of the sheltering effect of the Alps. For this reason, the Gulf of Genoa rarely if ever experiences the mistral and the Tyrrhenian Sea has winds much reduced and from the southwest. Due to the channeling effects, however, the Strait of Bonifacio will generally experience gale force westerly winds during mistral situations.

Since the mistral is characterized by the sinking and spreading of cold air along the coast of southern France, clear skies are observed over the Gulf of Lion. Considerable convective cloudiness is present over the Strait of Sicily, however, the result of the cold air being modified by the long trajectory over relatively warm water. This effect of air-sea interaction is apparent at point A on Figure III-3. Note also the line of convective clouds associated with the shear line extending from the northeastern tip of Spain, past Menorca, to the North African coast (B to C on Figure III-3). This line separates the strong wind area to the east from much higher winds and reduced seas to the west.

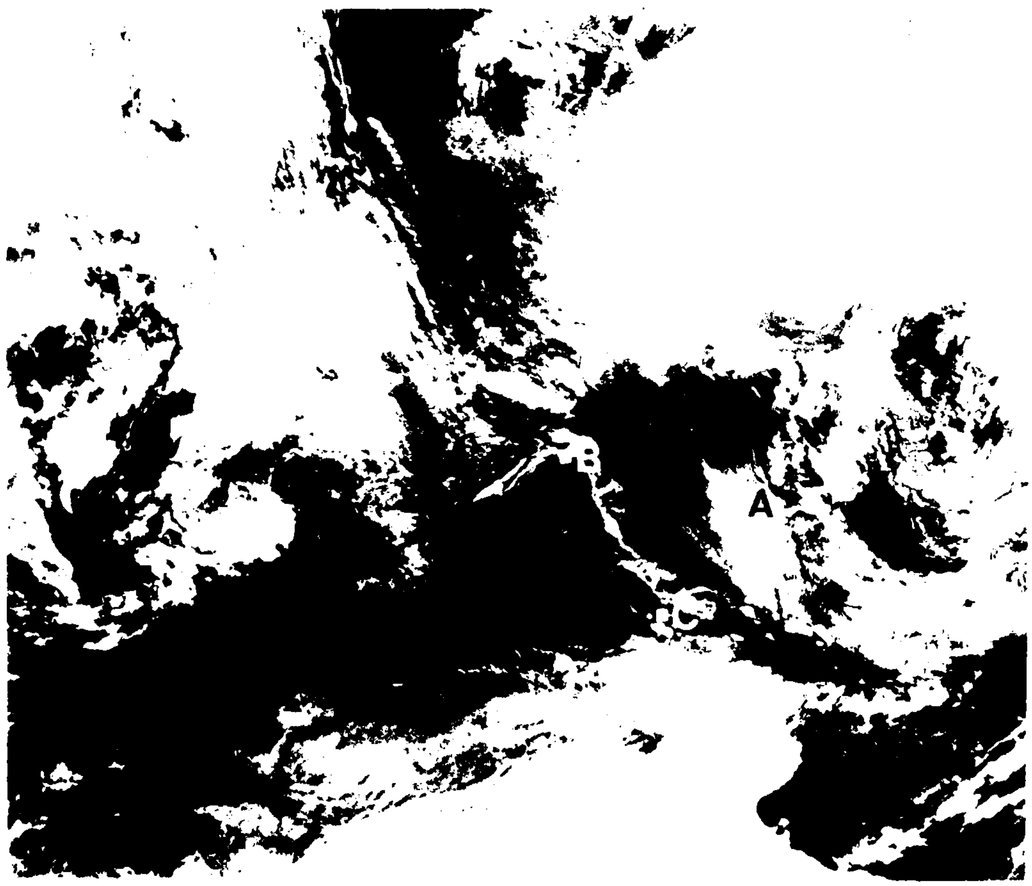


Figure III-3. High resolution satellite image, 1117 GMT, 18 October 1975.

2.2 SIROCCO

The sirocco is a southeasterly to southwesterly wind over the Mediterranean that originates over North Africa. Because the source regions of the air are deserts, the wind is extremely dry initially, warm in winter and hot in spring and summer. Although the sirocco's influence sometimes extends over the entire Mediterranean Basin, it is most pronounced in the Gulf of Gabes east of the Atlas Mountains.

In the Tyrrhenian Sea-Central Mediterranean Area, the sirocco generally occurs in the warm sector of cyclones moving across the area. In the Strait of Sicily and along the north coast of Tunisia, gale force sirocco winds also can blow in association with a developing North African low approaching Tunisia from the west. This situation is very common during the spring and early summer.

Weather associated with the sirocco shows a marked variation from southwest to northeast across the area. Along the north coast of Tunisia, visibilities are often reduced by dust storms, especially with developing North African lows.

Over the Tyrrhenian Sea, sirocco weather conditions depend on the length of the sea trajectory. If the wind direction is from the southeast (with a resulting long track over water), fog and stratus with drizzle occur to produce poor visibilities, especially on the east coast of Sardinia. If the sirocco blows from the southwest (as a result of a depression centered north or northwest of the Tyrrhenian Sea) the air will be hot and dry with suspended dust reducing visibilities, especially over the southern Tyrrhenian Sea.

Over the Gulf of Genoa and Ligurian Sea, the sirocco blows mainly from the south or southeast. Poor visibilities occur in low clouds and rain, especially near a frontal zone. Heavy swells can be expected during strong sirocco conditions in the Gulf of Genoa.

There are some important variations from the normal sirocco conditions. One case occurs along the north coast of Sicily where, due to a local foehn effect, high temperatures and low humidities can be expected even during conditions of general fog and low stratus. Another case occurs along the Italian Riviera where katabatic breezes blowing from the mountains to the north cause light northeasterly winds at such locations as Genoa, even though gale force sirocco winds are blowing out at sea. (For additional details see Section V, Para. 2.1.)

2.3 CYCLONE OCCURRENCES

2.3.1 Genoa Cyclones

Genoa cyclones are low pressure systems which develop south of the Alps and are found over the Gulf of Genoa, Ligurian Sea, Po Valley and northern Adriatic Sea.

Development Factors. Several factors that have special relevance in the development of depressions south of the Alps are:

(1) The thermal contrast between land and sea.

(2) Interaction between the polar front jet stream and the subtropical jet stream.

(3) Effect of northerly flow over the Alps, enhancing cyclogenetic activity along the southern slopes.

(4) Effect of the concave curvature of the southern slopes of the Alps, enhancing cyclonic formation.

(5) Blocking of cold fronts along the northern rim of the Alps.

Development Climatology. Genoa cyclogenesis can occur during all seasons, although the region of maximum cyclogenesis is located farther south in winter than in summer. The maximum density moves from the relatively warm water of the Gulf of Genoa during the winter to the hot land regions of the Po Valley during the summer.

Whether the cyclogenesis is initiated near the Gulf of Genoa or farther east near the Gulf of Venice depends on the amount of cold air penetrating the Po Valley from the northeast. If there is little or no cold air from the northeast entering the Po Valley, cyclogenesis will probably take place in the Gulf of Venice. Otherwise, the cyclogenesis will take place in its usual position to the west near the Gulf of Genoa.

Cyclone Movement. A majority of Genoa cyclones either remain stationary, or at least leave a residual trough, south of the Alps throughout their life history. The depressions, which do move, follow the two main tracks shown in Figure III-4. The first track, associated with strong southwesterly flow aloft, is in a northeasterly to north-northeasterly direction across the Alps. The second track, associated with a strong anticyclone over the Balkans, Turkey and the Black Sea, is in a southeasterly direction near the northern border of the Mediterranean Sea.

It should be noted that even after the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean Area, if a residual trough remains south of the Alps, new centers can develop and occasionally move southeastward along the west coast of Italy. Another common occurrence is for a Genoa cyclone, which has been moving southeastward, to become stationary just to the west of southern Italy. If this happens, a new center will usually develop to the east over the Ionian Sea.

Associated Weather Phenomena. The mistral is the primary weather phenomenon associated with the Genoa low. Although mistral conditions can develop locally along the south coast of France, major Genoa cyclogenesis is necessary for an extensive mistral to occur. Even after the Genoa low has moved eastward, the mistral will continue in association with a residual trough to the south of the Alps.

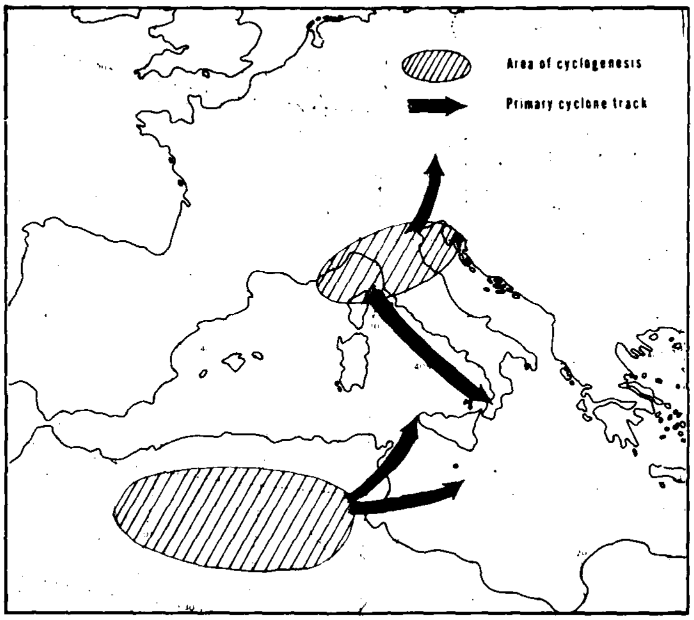


Figure III-4. Areas of cyclogenesis and tracks of cyclones which affect the Tyrrhenian Sea - Central Mediterranean Area.

Considerable shower activity along the west coast of Italy, with associated low ceilings and poor visibilities, is common with the Genoa low (most commonly along the cold front). Also in the Gulf of Genoa, within the residual trough, rapid deterioration of the weather can occur as cyclogenesis commences.

Along the west coast of Italy, the strongest winds occur when the Genoa low moves off to the southeast. Gale force northeasterlies are common under these conditions, partially as a result of katabatic wind flow off the Apennine Mountains.

2.3.2 North African Cyclones

The North African cyclone (see also Section V, Para. 2.5.1) develops over the desert region south of the Atlas Mountains and generally moves eastward south of the Atlas before recurving northeastward upon reaching the Tunisia/Gulf of Gabes region. It is of major importance when the depression deepens and recurves north-northeastward into the Strait of Sicily and the Tyrrhenian Sea-Central Mediterranean Area (see Figure III-4); this occurs several times from late autumn through spring.

Gale force winds with the North African cyclone are very common as it moves through the area. Sirocco winds occur ahead of the depression. Even stronger winds are likely to the west of the northeastward tracking low, especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb).

3. FORECASTING RULES

Tables III-1 through III-5 provide quick reference to the 67 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location within the area of interest. Observing stations locations are shown in Figure III-5, and listed in Table III-6.

Table III-1. Forecasting rules associated with the Genoa cyclone.

Cyclogenesis	Relationship to cold air	Rules 1-3
	Relationship to mistral	Rule 4
	Relationship to North African cyclone	Rule 5
	Satellite imagery	Rule 6
	Numerical forecast	Rule 7
Residual Lee Trough		Rules 8-10
Weather		Rules 11, 12
Other	Movement across Italian Boot	Rule 13
	Wind along Italian Coast	Rule 14

Table III-2. Forecasting rules associated with North African cyclone.

Cyclogenesis		Rules 15, 16
Movement	Numerical products	Rules 17, 18
	Other	Rules 19, 20
Surface Winds		Rules 21-23

Table III-3. Forecasting rules for mistral.

Southeastward Extent	Rules 24, 25
Eastern Boundary	Rules 26, 27
Strait of Bonifacio	Rules 28, 29
Air/Sea Interaction	Rule 30
Relationship to Genoa Cyclone	See Table III-1

Table III-4. Miscellaneous rules.

Frontal Activity	Analysis	Rules 31, 32
	Effect on Cyclogenesis	Rules 33, 34
	Other	Rules 35, 36
Station Reliability	Wind reports	Rules 37-40
	General	Rule 41
Sirocco		Rules 42, 43
Precipitation		Rules 44, 45
Local Effects		Rules 46-48
Fog		Rule 49a
Haze		Rules 49b-49d

Table III-5. Forecasting rules for ports and anchorages.

Naples	Sea and swell	Rules 50-55
	Wind	Rules 56, 57
	Clouds and weather	Rules 58-62
Genoa		Rules 63, 64
La Maddalona		Rules 65, 66
Livorno		Rule 67

Table III-6. List of observing stations.

Name of Station	Block No. (°Lat.,	Index No. °Long.)
Ajaccio	07	761
Bastia	07	790
Capo Palmaro	16	310
Capri	16	294
Genoa	16	120
Guardiavecchic/La Maddalena	16	506
Livorno	16	160
Messina	16	420
Milano	16	080
Naples	16	289
Pantelleria	16	470
Pisa	16	158
Ponza	16	280
Sanremo	43°48'N	7°46'E
Sciacca	16	436
Solenzara	07	765
Trapani	16	429
Ustica	16	400

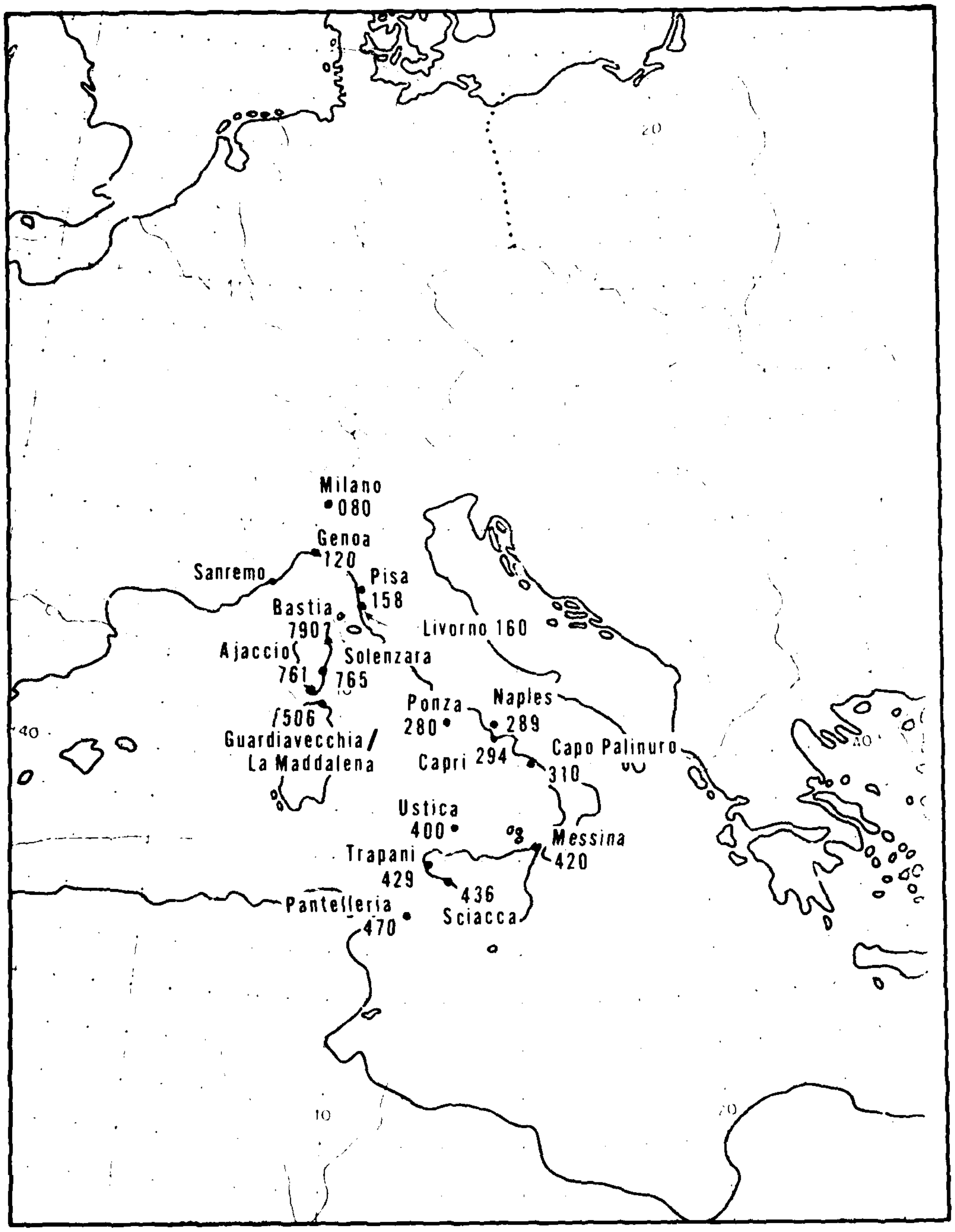


Figure III-5. Station locator map for the Tyrrhenian Sea - Central Mediterranean Area.

GENOA CYCLONES, CYCLOGENESIS RULES 1-7

1. A lee trough often is present in the Gulf of Genoa when a cold or occluded front is moving into western France. This lee trough remains stationary until the arrival of the front, at which time significant cyclogenesis occurs.

2. A good indication of rapid development of a Genoa cyclone is the appearance of cold air from the northeast in the Po Valley.

3. If Genoa cyclogenesis is predicted, the following rules can be used to decide whether it will occur in the Gulf of Genoa or to the east in the Gulf of Venice:

(1) If large amounts of cold air penetrate the Po Valley from the northeast, cyclogenesis can be expected in the Gulf of Genoa. This cyclone generally will move southeastward along the west coast of Italy.

(2) If little cold air penetrates the Po Valley from the northeast while a strong push is observed in the Gulf of Lion, cyclogenesis will probably take place in the Gulf of Venice. This cyclone occasionally may move southeast through the Adriatic Sea.

4. Genoa lows occur almost simultaneously with the onset of the mistral in the Gulf of Lion; conversely, these lows invariably form when conditions are right for the mistral to occur. (See rules on forecasting the mistral in Table II-1 of Section II.)

5. Complex low pressure systems with multiple centers at the surface are a common event in the western Mediterranean Basin. One center usually can be found in the Gulf of Genoa, while another is found over North Africa; a weak pressure gradient exists between the two systems. Which of these lows will develop depends greatly on the movement of an upper-level (500 mb) shortwave trough (SD minimum). If the SD minimum moves to the North African coast, for example, the low center in that region will develop rapidly, increasing the pressure gradient and causing easterly gales over the southern Tyrrhenian Sea.

6. When the long-wave ridge is in the eastern Atlantic, useful indicators in forecasting Genoa cyclogenesis can be obtained from following the positions of both the polar front jet and the upper-level shortwave troughs (SD minima) as seen on satellite imagery of the region near Iceland.

7. In the past it has been noted that the coarse grid numerical models have been of minimal value in forecasting Genoa cyclogenesis.

GENOA CYCLONES, RESIDUAL LEE TROUGH RULES 8-10

8. A residual low pressure trough generally remains over the Gulf of Genoa even after the primary low has moved well out of the region. This trough, with associated mistral, can remain for several days.

9. In the past it has been noted that numerical models tend to fill the lee trough south of the Alps much too soon. This trough usually remains in the Gulf of Genoa after a primary Genoa cyclone has moved away.

10. Centers of Genoa cyclones often can be poorly organized: strong pressure gradients, associated with a lee trough south of the Alps, frequently are found far from the cyclone's geographic center. This structure is well represented on the Fleet Numerical Oceanography Center's FIBSLP-MED* scheme.

GENOA CYCLONES, ASSOCIATED WEATHER RULES 11, 12

11. Cases of weak to moderate Genoa cyclogenesis cause important variations in the weather along with west coast of Italy. When analyzing these cases, the resolution of the 500 mb analysis should be fine enough to support tracking of the weak shortwave troughs (SD minima) associated with increased shower activity.

12. Convective activity associated with the Genoa low has a periodicity of about 18 hr, starting with the initial cold frontal passage. The periodicity is most pronounced with a stationary low. The most intense convective activity occurs at 36 hr intervals.

GENOA CYCLONES, MISCELLANEOUS RULES 13, 14

13. Surface lows moving southeastward through the Tyrrhenian Sea appear to fill when they reach the boot of Italy. When this occurs, a new center usually develops to the east over the Ionian Sea (and sometimes over the Adriatic Sea). Thus the center appears to jump across this land mass. The same effect is observed when a surface low crossing the Ionian Sea reaches Greece with the old center filling and a new center developing in the Aegean Sea.

14. Strong westerly winds associated with mistral conditions rarely reach the west coast of Italy. Winds usually will not reach gale force until after the associated Genoa low moves off to the southeast. Under these conditions, gale force northeasterly winds occur along the west coast of Italy.

---

*Fields by Information Blending methodology, Sea Level Pressure analysis for the Mediterranean area. FNOC formerly Fleet Numerical Weather Central (FNWC). See FIBSLP description in NAVWEASERV Numerical Environmental Products Manual, NAVAIR 50-1G-522, Section 4.1.

NORTH AFRICAN CYCLONES, CYCLOGENESIS RULES 15-16

15. A North African low is most likely to form over Tunisia when the long-wave trough is oriented northeast-southwest across the Tyrrhenian Sea. Cold continental polar air will be advected in from eastern Europe and a cold pocket of air (-25°C at 500 mb) will form between Sardinia, Sicily and Tunisia. The subtropical jet also will be evident over North Africa. Wind speeds at 500 mb over Tunisia and Libya will be 55 kt or more.

16. A small-scale "shadow" low that appears along the northern Algerian coast in association with a developing North African low (shown in Figure II-11) can sometimes become the dominant low in the Strait of Sicily.

NORTH AFRICAN CYCLONES, MOVEMENT RULES, 17-20

17. It has been observed in the past that numerical models move developing North African lows northeastward across the Atlas Mountains. The correct course is usually first to the east, south of the Atlas Mountains, then northeastward through the Gulf of Gabes.

18. Formation and movement of a Tunisian (North African) low is best detected/observed by using Fleet Numerical Oceanography Center's FIBSLP-MED. Earlier numerical models have not predicted movement with great accuracy.

19. An increase of middle cloudiness, as reported from coastal surface observing stations, is a good indication that a North African low is moving northeastward over the Mediterranean.

20. If a 500 mb trough extends from central Europe southward over North Africa, a North African low over Algeria may propagate northward, intensify in the Gulf of Genoa, and initiate a mistral.

NORTH AFRICAN CYCLONES, SURFACE WINDS RULES 21-23

21. It has been noted that the strongest winds associated with deepening North African lows, after the winds move over the Mediterranean, occur in the northwest sector of the system rather than in the eastern sector.

22. The strongest winds associated with North African lows occur west of the center when a pool of cold air aloft, seen at 500 mb, arrives (see Figure III-6).

23. When North African lows occur south of the Atlas Mountains, strong easterly to southeasterly winds are likely over the southern Mediterranean; these winds will cause high seas in the Strait of Sicily.

MISTRAL, SOUTHEASTWARD EXTENT RULES 24, 25

24. Strong mistral winds occur on the cyclonic side of, and underneath, the polar front jet axis. The mistral will extend as far southeastward as do the upper trough and polar front jet.

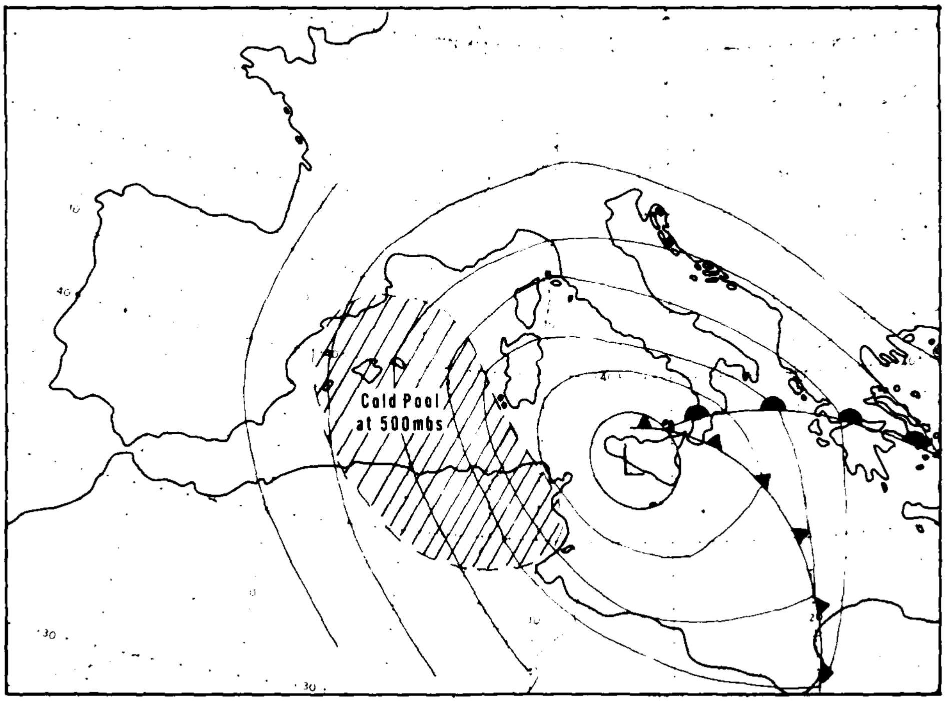


Figure III-6. Cold pool aloft associated with cyclone which has moved northeastward over the Mediterranean Sea. Strongest surface winds occur under cold pool.

25. During a mistral situation, wave clouds seen on satellite imagery (Figure III-3) to extend from Sardinia to Sicily are generally indicative of a gale force mistral that extends southeastward to the Strait of Sicily.

MISTRAL, EASTERN BOUNDARY RULES 26, 27

26. The eastern boundary of the mistral extends downwind from the western edge of the Alps through Sanremo.

27. Strong westerly winds associated with mistral conditions rarely reach the west coast of Italy, even when gale force mistral winds extend southeastward through the Strait of Sicily.

STRAIT OF BONIFACIO, RULES 28,29

28. During mistral conditions, westerly winds in the Strait of Bonifacio commonly achieve speeds up to 50 kt and extend in a narrow band for a considerable distance to the east. Seas up to 20 ft are often reported in this area.

29. Winds with an east or west component are funneled through the Strait of Bonifacio, fanning out on the lee side of the Strait in a "V" pattern; very rough seas can occur on each side of the "V".

MISTRALS, AIR/SEA INTERACTION RULE 30

30. Mistrals may occur during late autumn and early winter when air-sea temperature differences reach 6°C or more. Under these conditions, very poor visibilities can be expected in the lowest 30 meters of the atmosphere because of blowing spray. The greatest damage to harbor installations along the Algerian and Tunisian coasts occur during these mistrals because of the unusually high seas and swells that accompany the winds.

MISCELLANEOUS, FRONTAL ACTIVITY RULES 31-36

31. Shallow cold fronts approaching the Mediterranean Basin are greatly retarded by the mountain barriers. Deep cold fronts (i.e., those detectable at the 700 mb level) are not hindered by terrain features and sometimes undergo acceleration at the surface. Movements of troughs at the 400 mb level can be useful indicators in forecasting this acceleration.

32. It is difficult to plot the locations of fronts over the western Mediterranean Basin because of both the scarcity of reports over the water and the effects of terrain on coastal and island station measurements. Forecasters should be wary of designating lee-side troughs as being frontal in nature.

33. Cold fronts approaching the central Mediterranean become very active when they slow down. Multiple low centers with heavy rain are very common. This pattern remains stationary until the upper trough either moves eastward or fills.

34. Remnants of old cold fronts should be followed closely in the Mediterranean region. Cyclogenesis has originated along these fronts -- even after cloudiness associated with the fronts had disappeared -- when an upper level shortwave trough (SD minimum) approached from the west.

35. After the passage of a cold front at Naples, a period of 12-18 hr of clearing occurs along this part of the west coast of Italy even though the winds aloft remain strong southwesterly.

36. Warm frontogenesis commonly occurs over the Tyrrhenian Sea when southeasterly flow is established at the surface. It appears that warm, dry air advected northward from North Africa does not pick up adequate moisture to form clouds until it reaches this sea area.

MISCELLANEOUS, STATION RELIABILITY RULES 37-41

37. Wind observations at the island station Ustica have appeared to be much too strong to be representative of conditions for the surrounding water area.

38. The surface winds reported from Ponza have been highly reliable as representative of the surrounding sea area. However, during periods of strong katabatic flow at Naples (a northeasterly wind), this station is too far from the coast to experience these winds.

39. The wind report at Pantelleria is very representative of the surface winds in the Strait of Sicily.

40. The surface wind report at Messina is not representative of winds in the Strait of Messina. Southwesterly gales, a common event in the Strait, are not indicated by the wind at Messina.

41. Past experience indicates that the reliability of hourly reporting stations along the Italian coast is questionable, especially during the night.

MISCELLANEOUS, SIROCCO RULES 42, 43

42. During periods of sirocco over the Mediterranean, a low-level jet is likely just below the top of the very marked temperature inversion common during the sirocco. Wind speeds reaching 70-80 kt, with heavy turbulence associated with the strong vertical wind shear, have been observed in this jet.

43. Sirocco conditions crossing the Island of Sicily produce strong and gusty foehn-type winds on the north and east sides of the island; the foehn wind, for example, is evident at the entrance to the Catania Valley. During these foehn-type wind occurrences, ships experience better sailing conditions south of Sicily than north of the island. Sea conditions are better north of Sicily because of the small fetch.

MISCELLANEOUS, PRECIPITATION, LOCAL EFFECTS RULES 44-48

44. During periods of southerly surface flow in the central Mediterranean, convergence zones between southeasterly and southwesterly winds are frequently observed. These convergence zones result in heavier precipitation and lower visibilities. Fronts are not associated with this phenomenon initially, but they may develop later.

45. During the winter half of the year along the west coast of Italy, maximum occurrence of convective activity is in the early morning (0300-0800 LT) and minimum occurrence is in the late afternoon and early evening. In the mountains to the east, however, this diurnal variation is reversed.

46. Dry, moderate-to-strong (15-25 kt), north-to-east winds during the winter have produced steam fog along the Italian coast from Genoa to Pisa, out to 35 n mi offshore. Visibilities in this fog are reduced to 1-2 n mi although the dewpoint-temperature spread measured at a carrier's flight deck level may exceed 4°F.

47. Winds with a north or south component are funneled through the Strait of Messina, fanning out in a "V" on the downwind side; rough seas occur on each side of the "V."

48. Strong northerly winds can be expected in the Gulf of Genoa within 6-8 hr if (1) the 1034 mb isobar is present along the crest of the Alps north of the Gulf of Genoa and (2) increasing northerly winds are observed at Milano.

MISCELLANEOUS, FOG/HAZE RULE 49a-d

49a. Likely areas for the occurrence of fog during the summer are along the coasts of Corsica and Sardinia, along the west coast of Italy, and between Sardinia and the North African coast.

49b. The occurrence of salt haze is a serious problem for flight operations over the Mediterranean. This type of haze has the following properties:

(1) It is most prevalent during the summer and early autumn.

(2) Its color ranges from bluish white to light yellow, as opposed to brown for dust haze.

(3) Salt haze scatters and reflects light rays much more than dust haze.

(4) It sometimes extends to over 12,000 ft and has been reported up to 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi, the slant visibilities for a pilot making a landing approach may be near zero, especially if the approach is in the general direction of the sun.

(6) Salt haze is sometimes thicker aloft than at the surface.

(7) The haze is less of a problem after sunset because its associated poor visibility is caused partially by scattering and reflection.

49c. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing, such as occurs when there is a strong ridge present both at the surface and aloft.

49d. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. However, visibilities will improve if there is an increase in the wind speeds at the 850 and/or 700 mb levels.

PORTS AND ANCHORAGES, NAPLES RULES 50-62

50. *Maximum seas (ft), as a function of wind direction and speed, for the* outer harbor at Naples are:

	Speed (kt)					
Direction	18	20	22	24	26	28
090-180°	4.5	6	6.5	7.5	8.5	10
180-280°	6	8	10	13	15	19
280-360°	5	6	7	8	9	11

These relationships were derived under the assumption of one-third fully arisen sea, since the islands of Capri and Ischia are 18 and 22 n mi distant, respectively. Also added to these sea heights are the seas developed by the limited fetch inshore from these islands. It should be noted that since neither of these islands interferes with seas from the southwest quadrant (180-280°), the heights for those directions are fully arisen.

51. Steady winds of 15 kt or more for a period of 12 hr or more at the following stations will adversely affect boating in the harbor at Naples:

(1) Winds from west or northwest at:
Guardiavecchia (LIEG), Sardinia
Solenzara (LFKS), Corsica
Ajaccio (LFKJ), Corsica
Bastia (LFKB), Corsica

(2) Winds from south or southwest at:
Ustica (LICU), Sicily
Sciacca (LICS), Sicily
Trapani (LICT), Sicily

52. Seas 8-10 ft in Naples harbor in less than 12 hr should be predicted if southeasterly (130° or greater) winds 20-30 kt are occurring along the southwest coast of Italy.

53. Moderate south-southwest prefrontal winds will generate high seas in Naples harbor.

54. Northwesterly wind over Naples harbor will flatten seas generated by a southeast-through-west wind. The stronger the wind, the faster the seas will diminish.

55. Because of fetch limitations, northeast winds over Naples harbor will seldom generate seas to hamper boating conditions.

56. Fast-moving cold fronts (up to 40-50 kt) approaching from the west produce surface northeasterlies in the Naples area following the frontal passage. A good indication of frontal passage at Naples is the wind's becoming variable 10-15 kt at Capri and Capo Palinuro.

57. The islands of Capri and Ponza block strong north-northwesterly winds from entering the harbor at Naples. Wind speeds may differ by as much as 40-45 kt between Capri and the outer harbor at Naples.

58. In the Naples area, convective cells have small horizontal size but great intensity. Peak gusts normally are of the order of 40-45 kt with mean wind speeds of 20-25 kt.

59. In the Naples area, it appears that convective activity during the winter reaches its greatest intensity over the water just before moving inland. These showers are much weaker inland at NOCD Naples than on the coast.

60. It is a general rule at Naples that cumulus and stratocumulus activity is at a minimum during the period from mid-afternoon to midnight.

61. Visibilities are usually poor at NOCD Naples because of industrial pollutants. Smog during summer, a common occurrence, reduces visibilities to 2-3 n mi. VFR conditions at the airport, 1500 ft and 5 n mi, are rarely met.

62. The generally poor visibilities at Naples can be expected to improve rapidly 1-6 hr before the passage of a cold front.

PORTS AND ANCHORAGES, GENOA, LA MADDALONA, LIVORNO RULES 63-67

63. The carrier anchorage at Genoa is completely exposed to swell from the south. Southeasterly gale force winds in the Tyrrhenian Sea, associated with a cyclone over the western Mediterranean, produce 4-6 ft southeasterly swells. The local wind at Genoa will usually remain from the north throughout such periods.

64. Topographic effects at Genoa produce surface winds which often oppose the gradient. Southwesterly winds occur only rarely; normal wind directions are from southeasterly to northeasterly.

65. The anchorage at La Maddalena, Sardinia, is protected from all quarters except the southeast by mountains, so the prevailing westerlies and northwesterlies experienced in the Strait of Bonafacio do not affect the area. Strong southeasterlies of 20 kt or more produce 4-6 ft seas in the anchorage.

66. The open passes adjacent to the anchorage at La Maddalena, Sardinia, which are used by USN small craft for ferry work are not protected from the prevailing westerlies and northwesterlies. Extensive mistral situations affect the open passes with both gale force winds and high seas. In the open passes during mistral situations, wind velocity is 15-25 kt greater and seas 8-10 ft higher than at the anchorage.

67. The anchorage at Livorno is considered dangerous because high winds can produce hazardous sailing conditions and cause larger vessels to drag anchors.

IV. ADRIATIC SEA AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Adriatic Sea Area* shown in Figure IV-1 encompasses the Gulf of Venice, the Adriatic Sea, and the important sea connection to the Ionian Sea, the Strait of Otranto (see also Section V).

The major topographical features of the area are the Alps to the north, the Apennine Mountains of Italy to the west, and the Dinaric Alps of Yugoslavia to the east. Other topographical features of importance are the Po Valley separating the Alps from the Apennine Mountains, and the Trieste Gap between the Alps and the Dinaric Alps. Such features frequently combine to produce one or more of the three significant weather effects: channeling of air flow; prominent corner effects; and obstacle effects produced by air flow over mountain barriers.

1.2 SEASONAL WEATHER

The seasonal weather patterns in the Adriatic Sea Area are controlled to a large extent by the monsoonal behavior of the Eurasia land mass. During the winter (November through February), the great continental anticyclone of Eurasia develops and extends southwestward towards the Balkans. Cold bora winds are the usual result of this weather pattern. Stormy and unsettled weather is also common during the winter with the high incidence of cyclones moving into this area.

During the summer (June through September), the Eurasian winter anticyclone is replaced by the great continental depression centered over Southwest Asia with an extension westward over Asia Minor. Combined with an extension of the Azores anticyclone northeastward towards the Alps, the summers in the Adriatic Sea area are generally warm and dry with light winds.

The transitional seasons, spring and autumn, are of considerably different length. Spring extends over a relatively long period (March through May) and is noted for changeable weather with periods of stormy winter-type weather alternating with a number of false starts of settled summer-type weather. Autumn is usually very short, lasting about the month of October, and is characterized by an abrupt change to winter-type weather.

---

*Comprises British forecast sea areas Venice and Centaur; see Figure 1b in the Introduction.

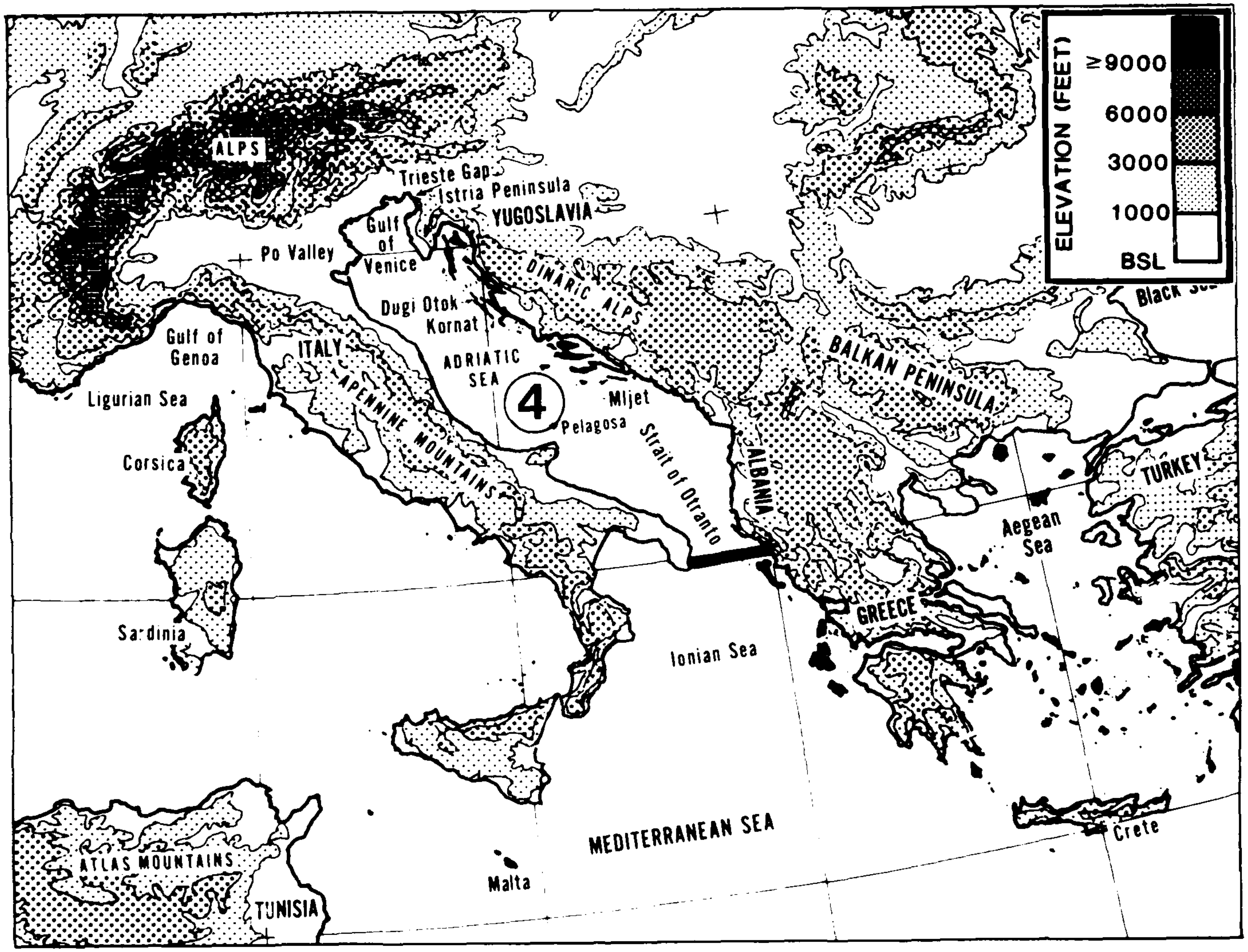


Figure IV-1. Topographical map of Adriatic Sea Area.

2. REGIONAL WEATHER PHENOMENA

2.1 BORA

2.1.1 Introduction

The bora is a fall wind whose source is so cold that when the air reaches the coast, the dynamic warming caused by subsidence is insufficient to raise the air temperatures of the region to the level normally experienced. The bora is a true katabatic wind insofar as the kinetic energy of its gusts is derived from the potential energy of cold air that spills over coastal mountain ranges and "falls" down the steep slopes to the sea.

The bora occurs when cold air accumulates over the Balkan Peninsula, especially over Yugoslavia. The depth of the cold air reservoir has to reach at least up to the mountain passes for the bora to commence. There are two types of weather patterns which produce the bora:

(1) An anticyclonic weather pattern characterized by strong high pressure over Central Europe, but with no well-developed low to the south (Figure IV-2a).

(2) A cyclonic weather pattern characterized by a depression in the southern Adriatic Sea or in the Ionian Sea (Figure IV-2b).

In each case, the pressure is higher on the European side of the mountains and lower over the Mediterranean.

2.1.2 Characteristics of the Bora

Extent. The bora is most common in the Adriatic Sea Area where it flows mainly from the northeast through gaps in the Dinaric Alps, the best known of which is the Trieste Gap (see Figure IV-1). Sometimes the bora is very localized, extending only a few miles seaward from the coast of Yugoslavia. At other times, the bora covers the entire Adriatic Sea. Its normal southward extent, however, is about 60 n mi south of the Strait of Otranto.

With high pressure over Central Europe and the Balkans and with relatively low pressure over the south central Mediterranean, the bora can extend as far south as Malta. However, because of the long sea trajectory. the air is much warmer and moist at its southern extremity. With strong bora conditions over the Adriatic Sea, strong northerly to northeasterly winds may extend across the Apennine Mountains of Italy as far to the west as Corsica and Sardinia. Bora type winds are also frequently found in the Aegean Sea extending southward across the Mediterranean to Crete (see Section VI, Para. 2).

Wind Direction. The bora blows generally northeasterly over the Adriatic Sea, although with important variations. The direction of the wind along the Yugoslavian coast depends on the orientation of adjacent mountains, gaps and valleys. The bora is northeasterly at Trieste, but farther south its characteristic direction is often east-northeasterly to easterly. Over the

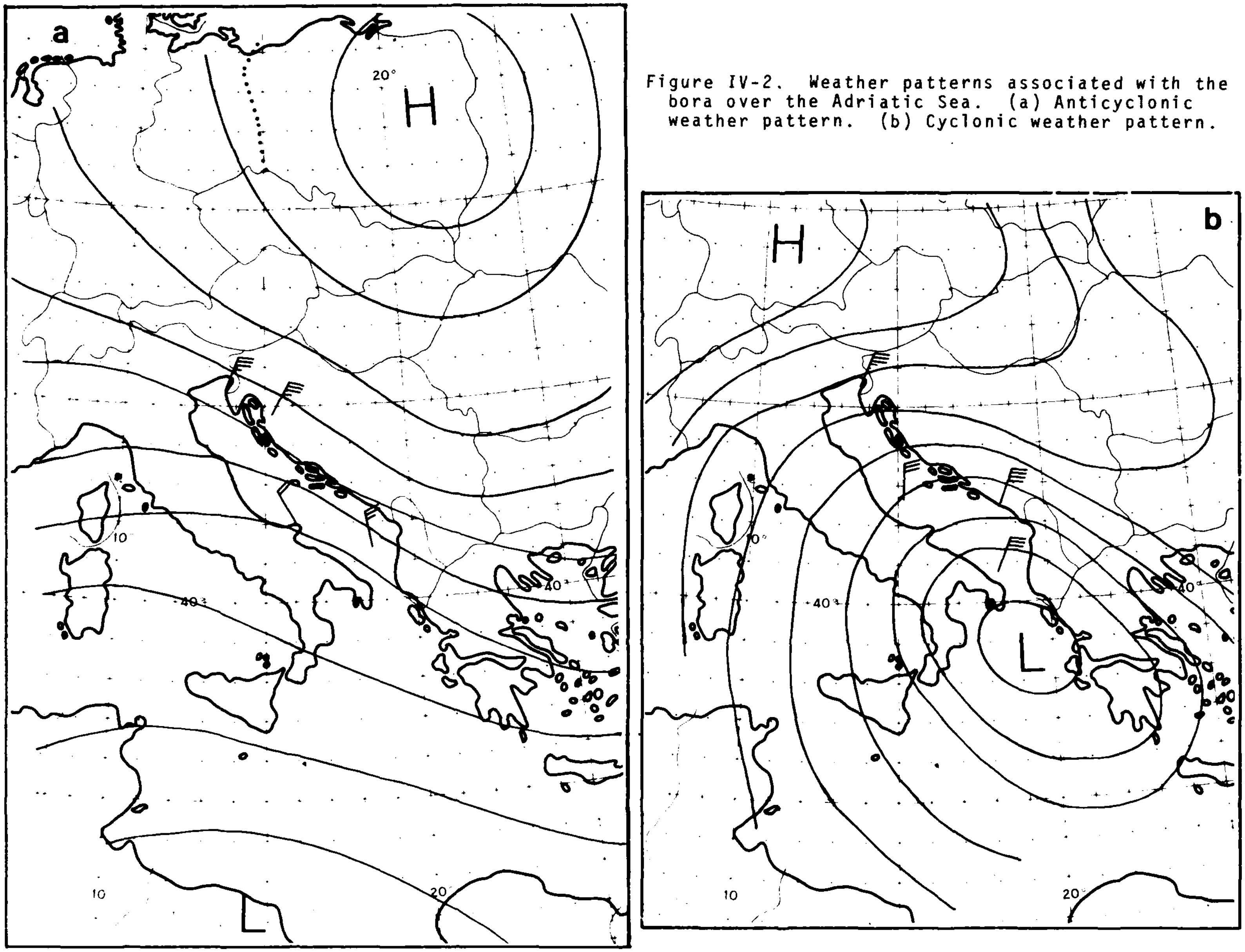


Figure IV-2. Weather patterns associated with the bora over the Adriatic Sea. (a) Anticyclonic weather pattern. (b) Cyclonic weather pattern.

open sea, the direction of the bora is usually northerly to northeasterly, while on the Italian coast, south of Ancona, the wind almost always backs to a north-northwesterly direction. This general wind pattern is illustrated in Figure IV-3.

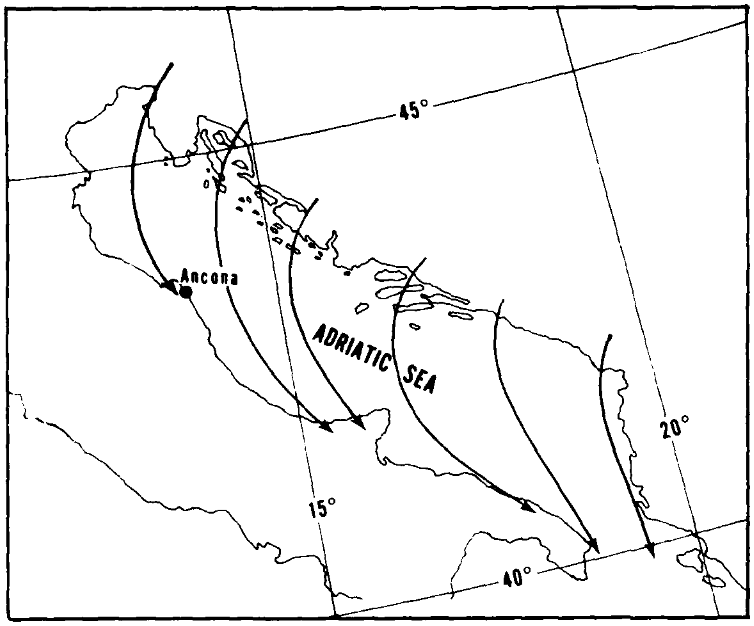


Figure IV-3. General wind pattern over the Adriatic Sea during a bora.

Wind Strength. Strongest winds associated with the bora occur along the eastern shore of the Adriatic Sea from Trieste to the Albanian border. The bora on the average is most violent to the north, with decreasing intensity southward. The strength depends to a great extent on topographical features adjacent to the coastline. The greatest intensity of the bora occurs in areas where the mountain peaks are at least 2000 feet above sea level and inland not more than two or three miles.

At Trieste where topographical features are most favorable for the production of bora-intensity winds, hourly wind speeds have been measured at an average speed of 70 kt with gusts exceeding 110 kt.

Over the open water of the Adriatic Sea, the bora is generally less intense, although gale force winds (34-47 kt) are very common. The frequency of the gale force bora in the open sea is greater for the cyclonic type of weather pattern than for the anticyclonic pattern. During the cyclonic pattern the strongest winds are usually observed over the southern Adriatic Sea.

Frequency and Duration. Bora winds are most common during the cool season of the year (November through March). At Trieste, where the bora is most common, the frequency of gale force winds (34-47 kt) varies from one day or less per month during the summer to six days or more per month during the winter.

The average duration of a continuous gale force bora over the Adriatic Sea is about 12 hr, but the winds sometimes will last up to two days. In contrast, the average duration of a bora that reaches gale force at some time in its history over the Adriatic Sea is 40 hr, with a maximum duration of about five days. At Trieste, the average duration of a gale force bora varies from three days in winter to one day in summer. However, the bora has been known to last for up to 30 days at Trieste without a significant lull.

Diurnal Variation. There is a noticeable diurnal variation at coastal Adriatic stations during bora conditions. During the day, along the eastern shore of the Adriatic Sea, the sea breeze counteracts the offshore flow of the bora. This effect leads to a decrease in the strength of the bora between 1200 LT and 1800 LT. The primary minimum strength of the bora winds at coastal stations is at approximately 0000 LT due to a decrease of convectional mixing at night.

Clouds and Weather. The bora wind is basically dry as the result of its katabatic nature. Thus skies are clear and visibilities are excellent in the lee of the mountains. A thick cloud bank associated with upslope motion from the interior is present over the mountain crests; this bank subsequently dissolves in the descending air. These conditions occur during the anticyclonic-type bora.

Weather conditions associated with the bora during a cyclonic weather pattern can be quite different. With a depression located just to the south of the Adriatic Sea, low clouds with drizzle and/or rain reducing visibilities over the Adriatic Sea are common.

2.1.3 Objective Analysis Scheme Capable of Delineating the Bora

A serious problem in analyzing a possible bora situation over the Adriatic Sea is the likely existence of an extremely strong pressure gradient over the Dinaric Alps, a gradient which is not reflected by strong winds over the open water. For an analysis scheme to be successful in delineating a bora situation, it must not spread pressure information across a topographical barrier. The Fields by Information Blending methodology, Sea-Level Pressure analysis (FIBSLP) for the Mediterranean area produced by Fleet Numerical Weather Central (FNWC)*, now Fleet Numerical Oceanography Center (FNOC), is designed to handle this problem.

---

*For a more complete description of FIBSLP see U.S. Naval Weather Service Numerical Environmental Products Manual, NAVAIR 50-1G-522, Section 4.1.

The FIBSLP for the Mediterranean area includes the following features:

(1) A grid spacing of 0.25 of the standard FNWC grid spacing. This grid length is approximately 50 n mi.

(2) A method of reducing the weighting factors assigned to pressure reports for high elevation stations so that unreliable data will not effect the analysis.

(3) A method by which pressure information is disassociated across a mountain barrier. Thus, high pressure on one side (in the cold air) will not modify the analysis on the other side (in the warm air).

The capabilities of the FIBSLP for the Mediterranean area -- in delineating cases of strong bora over the Adriatic Sea from cases when bora winds do not extend out from the coast -- can be seen by comparing the weather situation on 26 January 1973 with that on 29 January 1973.

The FIBSLP for the Mediterranean area analyses at 1200 GMT 26 January 1973 (Figure IV-4) shows as a significant feature the occurrence of a tight pressure gradient across the Dinaric Alps in the vicinity of Point A; at the same time, a slack gradient is analyzed over the Adriatic Sea (Point B). These analyses indicate that bora conditions have not advanced out over the water. This statement seems to be verified by the light winds reported at coastal stations surrounding the Adriatic Sea.

A more positive verification of the lack of bora conditions over the Adriatic Sea is found on the DMSP imagery in Figures IV-5a and IV-5b for 1009 GMT. These images show that the cloud bank usually found in the vicinity of Point A during bora conditions is lacking. Most of the white area in the region of Point A in Figure IV-5a is snow cover. However, over the northern Adriatic Sea in the vicinity of Point B, there is extensive low cloud cover (compare Figures IV-5a and IV-5b). Because of the drying effect of the descending air west of the Dinaric Alps during a bora, an extensive bank of low clouds would not be expected over the open water. In this particular case, strong bora winds were present on 25 January. The low clouds forming over the Adriatic Sea on 26 January indicated an end of the bora.

The other situation for 29 January 1973 is an example of a bora associated with a cyclonic weather pattern. The FIBSLP for the Mediterranean area at 1200 GMT shows an intense cyclone located near the southwest coast of Greece (Figure IV-6). The tight pressure gradient over the Adriatic Sea indicates strong bora conditions over the entire area. This situation is quite different from that of 26 January (Figure IV-4) when the strong pressure gradient occurred only across the Dinaric Alps with weak gradients over the water. The observed coastal winds in Figure IV-6 confirm the existence of the bora. Further support is given by the DMSP imagery for 1107 GMT (Figures IV-7a

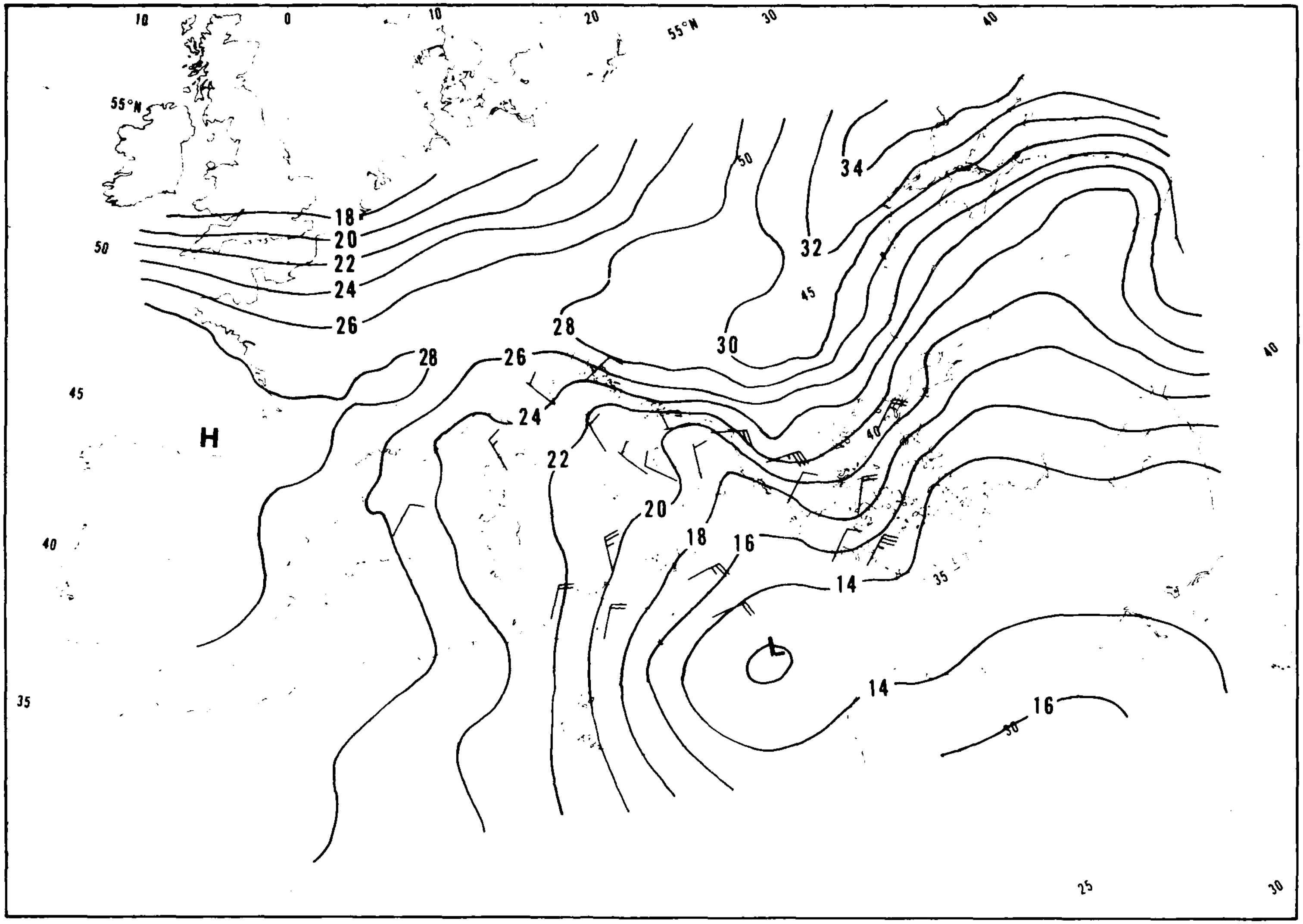


Figure IV-4. FIBSLP analysis, 1200 GMT, 26 January 1973.

AD-A102 635 NAVAL ENVIRONMENTAL PREDICTION RESEARCH FACILITY MON--ETC F/G 4/2
HANDBOOK FOR FORECASTERS IN THE MEDITERRANEAN. PART 2. REGIONAL--ETC(U)
DEC 80 L R BRODY, M J NESTOR
UNCLASSIFIED NEPRF-TR-80-10-PT-2 NL

AD A
102635

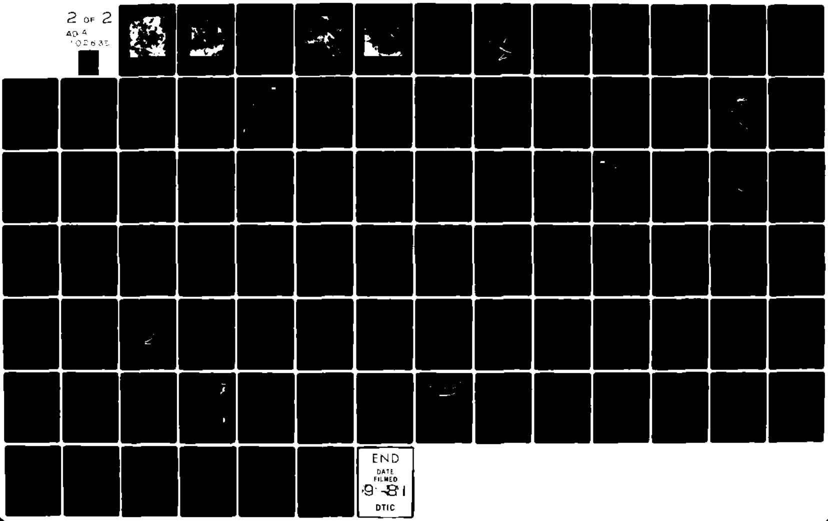


Figure IV-5a. DMSP high-resolution visual image, 1009 GMT, 26 January 1973.

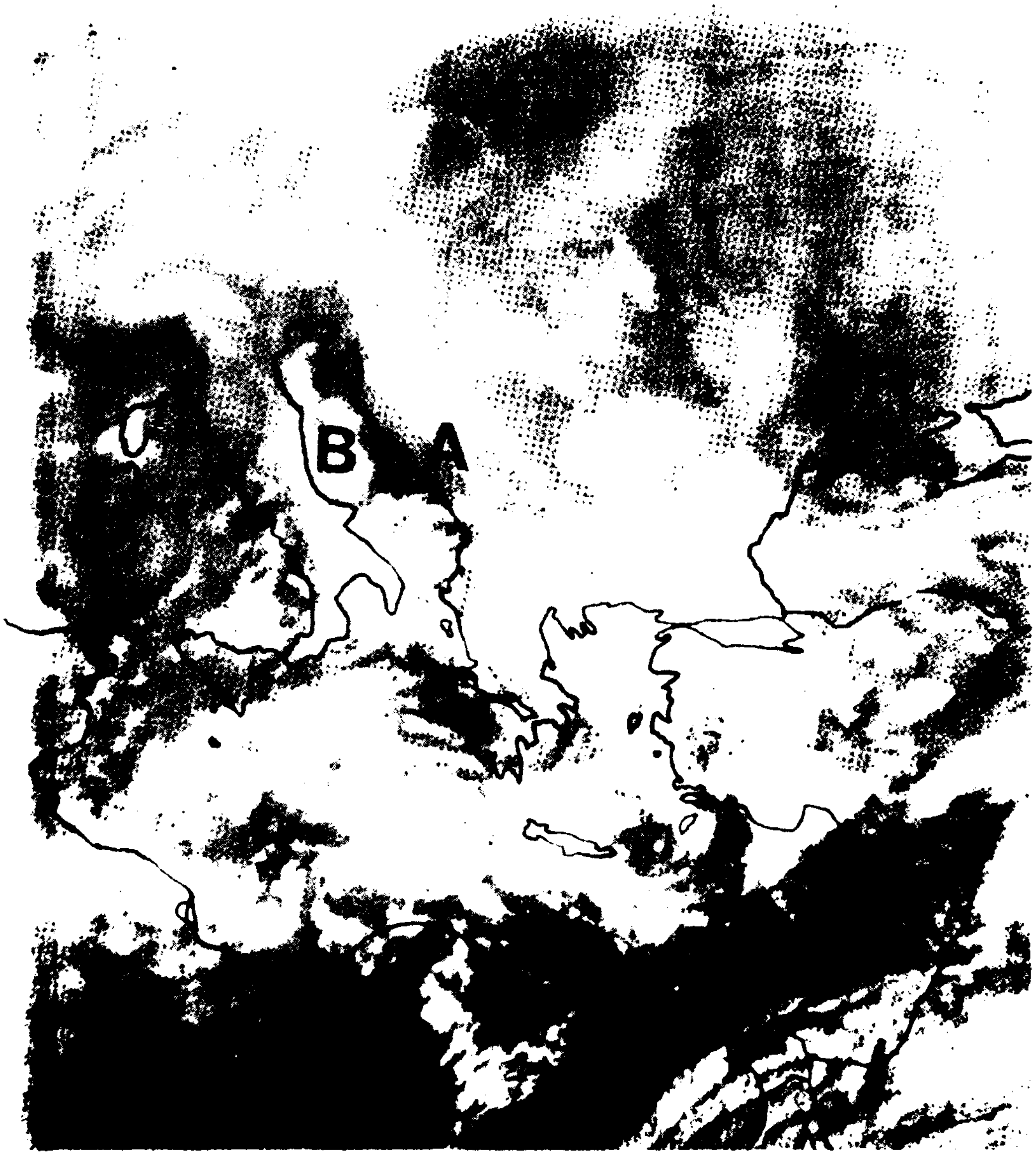


Figure IV-5b. DMSP IR image, 1009 GMT, 26 January 1973.

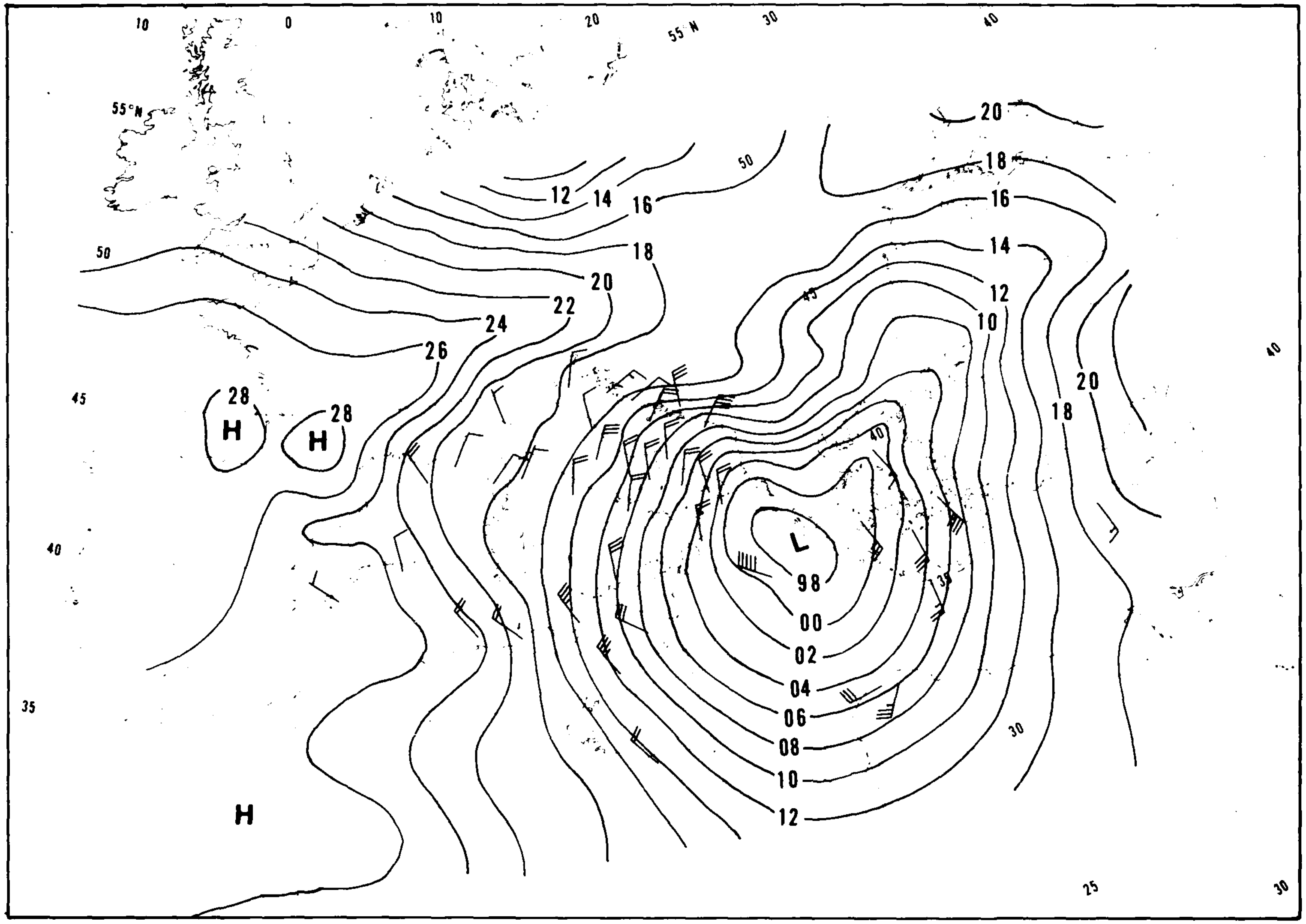


Figure IV-6. FIBSLP analysis, 1200 GMT, 29 January 1973.

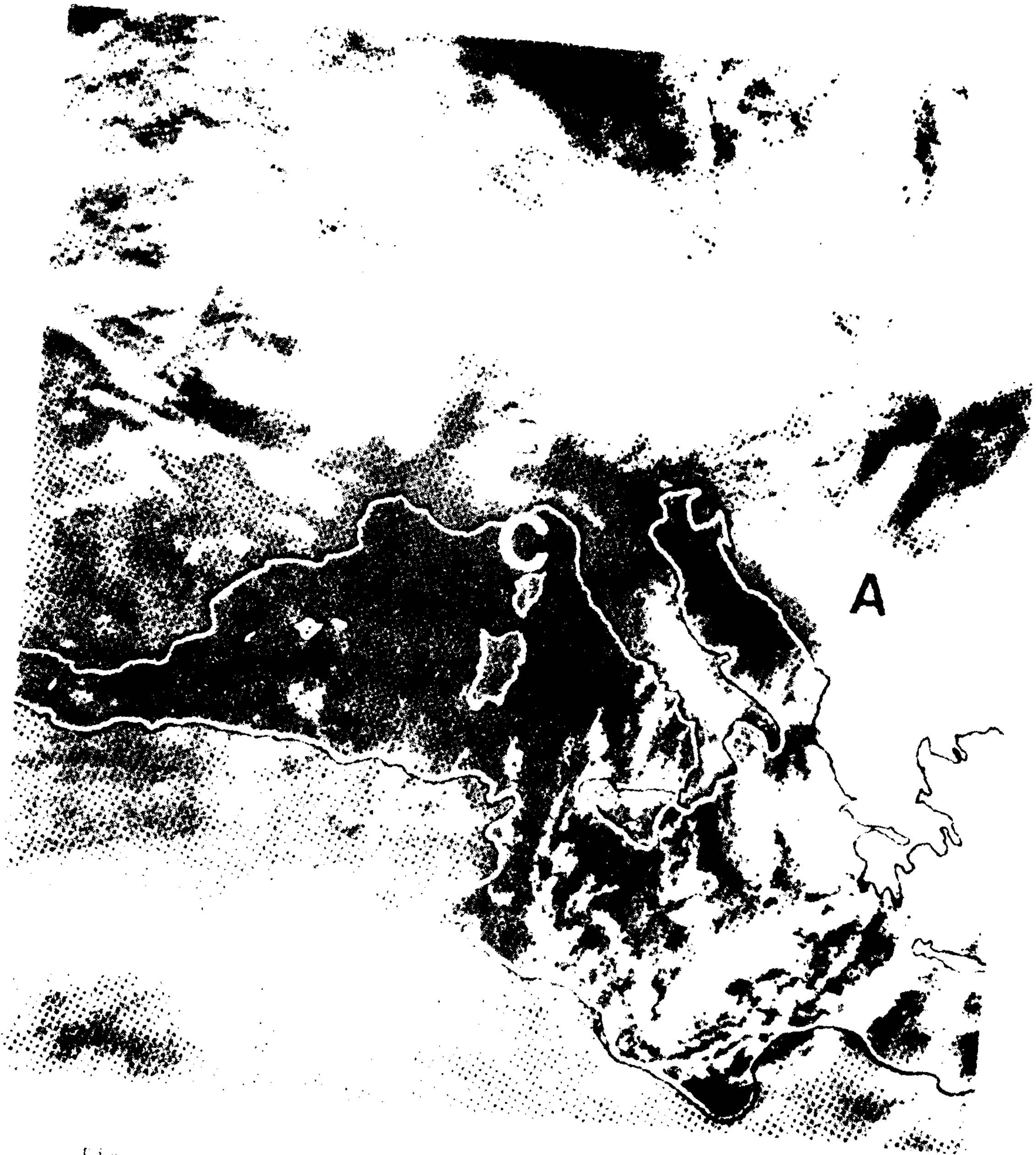


Figure IV-7a. DMSP high-resolution visual image, 1107 GMT,
29 January 1973.

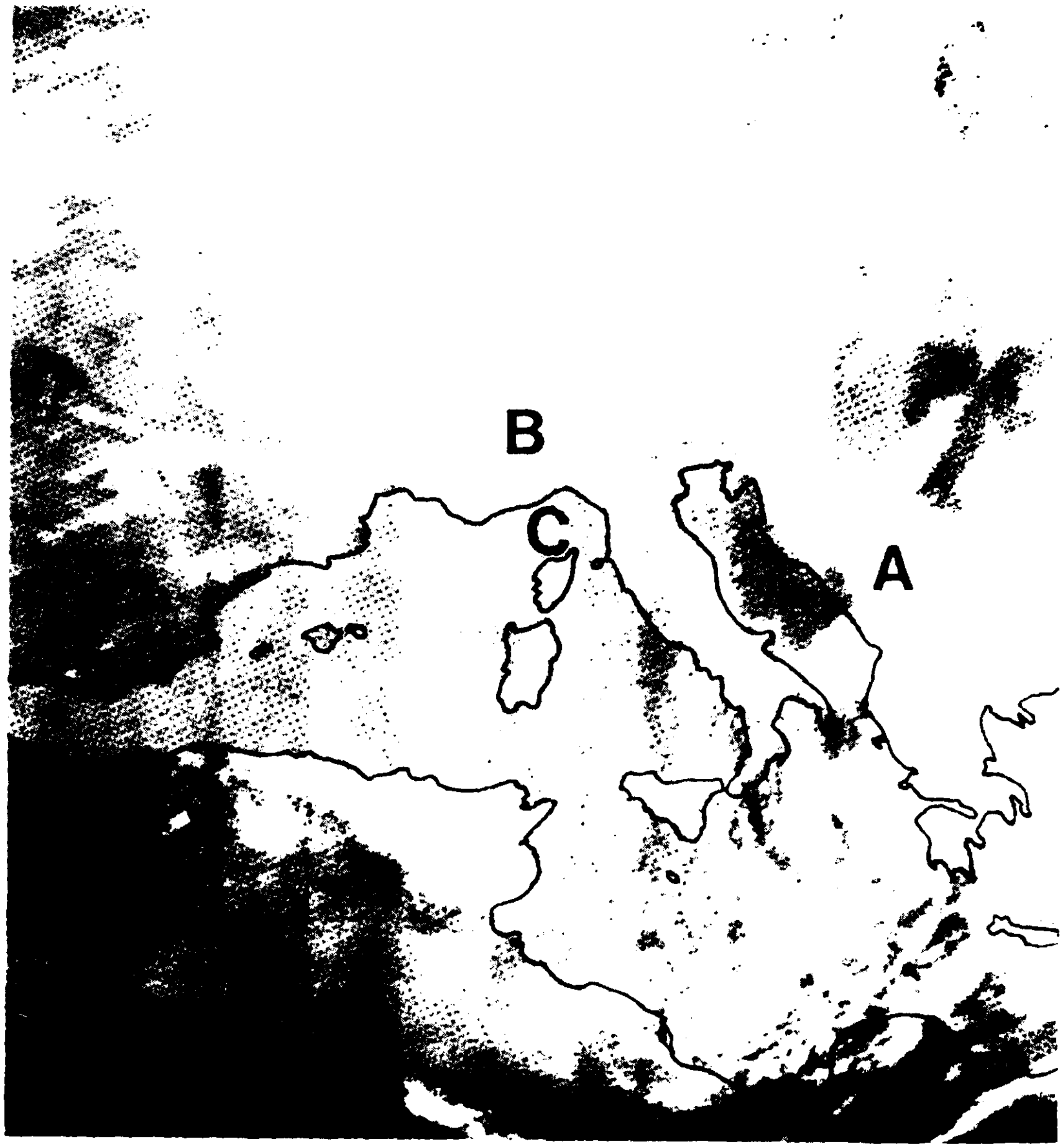


Figure IV-7b. DMSP IR image, 1107 GMT, 29 January 1973.

and IV-7b), which show the bank of low clouds over and to the east of the Dinaric Alps, north of Point A (the edge of the higher clouds associated with the intense cyclone).

2.2 SIROCCO

The sirocco is a southeasterly to southwesterly wind over the Mediterranean originating over North Africa. Although sirocco conditions sometimes are found in the Adriatic Sea, they occur most frequently east of the Atlas Mountains in the vicinity of the Gulf of Gabes.

Over the Adriatic Sea area, the sirocco normally occurs within the warm sectors of cyclones passing either north or west of the region. These cyclones originate either over North Africa or south of the Alps. Sirocco conditions occur in the latter case when the circulation extends far enough southward to draw air from the North African region.

Unlike the start of the bora, the onset of the sirocco is generally gradual. It occurs more frequently in the southern part of the Adriatic Sea with a decrease in frequency northward. Although the sirocco is not as strong as the bora, winds frequently reach gale force (34-47 kt), especially in the winter and spring. The average duration of a sirocco in which speeds of gale force are reached at some point in its history, is about 30 hr with a maximum duration of four to six days. The average duration of continuous gale force winds during a sirocco is 10-12 hr, and occasionally as long as 36 hr. The maximum wind speeds likely during a sirocco is about 55 kt.

As the sirocco crosses the relatively cool water of the Mediterranean Sea, it experiences considerable modification, especially near the water surface. By the time the sirocco air mass reaches the Adriatic Sea area, it has become saturated in the lowest layers with associated low clouds, fog, and drizzle, and resultant poor visibilities. Rain is common near frontal zones. Within the Adriatic Sea area, conditions tend to be worse northward from the island of Pelagosa: cloud bases lower, and heavy fog is likely, especially from October to January. Due to the orientation of the Adriatic Sea, heavy seas are likely during sirocco conditions near the Gulf of Venice where the fetch is the entire length of the Adriatic Sea.

2.3 CYCLONE OCCURRENCES

2.3.1 Genoa Cyclones

Genoa cyclones are low-pressure systems which develop to the south of the Alps in the region incorporating the Gulf of Genoa, Ligurian Sea, Po Valley, Gulf of Venice, and northern Adriatic Sea. Although several factors are important in cyclogenesis (see Section III, Para. 2.3.1), the development of the

cyclone near the Gulf of Venice -- as opposed to the west near the Gulf of Genoa -- depends on the amount of cold air penetrating the Po Valley from the northeast. If there is little or no cold air entering the Po Valley, the cyclogenesis will probably occur in the Gulf of Venice; otherwise, the cyclogenesis will tend to occur to the west.

Genoa cyclones usually remain stationary (or at least leave a residual trough) south of the Alps throughout their life history. If the cyclones do move, they generally follow one of the two main tracks shown in Figure IV-8. The first track, common for cyclones developing in the Gulf of Venice, is a northeasterly to north-northeasterly direction across the Alps. This track is associated with strong southwesterly flow aloft. The second track, associated with a strong anticyclone over the Balkans, Turkey and the Black Sea, is in a southeasterly direction from the Gulf of Genoa towards the Ionian Sea.

If the cyclone is moving southeast in association with high pressure over the Balkans, a gale force bora is extremely likely by the time the depression moves into the Ionian Sea (for example, see Figure IV-6). With strong southwesterlies aloft, sirocco conditions are likely in association with a Genoa cyclone if the circulation of the depression extends southward to North Africa, allowing air from the desert source to move northward.

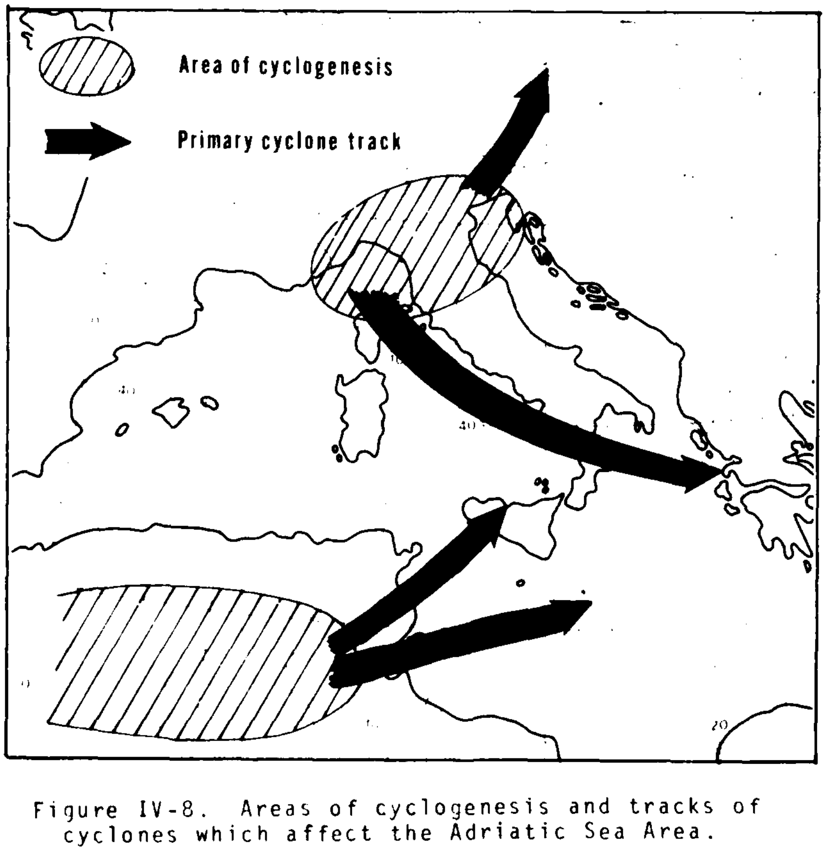


Figure IV-8. Areas of cyclogenesis and tracks of cyclones which affect the Adriatic Sea Area.

2.3.2 North African Cyclones

The North African cyclone (described in Section V, Para. 2.5.1) develops over the desert region south of the Atlas Mountains. It generally moves eastward, south of the Atlas, before recurving northeast upon reaching the Tunisia/Gulf of Gabes region where it affects the Adriatic Sea area. This situation is most likely to occur from late autumn through spring.

If the North African cyclone passes west of the Adriatic Sea, sirocco conditions are likely because the air in the warm sector has come from the deserts of North Africa. Considerable moisture will have been added to the air, however, causing low clouds, fog and rain, with attendant poor visibilities.

3. FORECASTING RULES

Tables IV-1 through IV-4 provide quick reference to the 23 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location within the area of interest. Observing stations locations are shown in Figure IV-9, and listed in Table IV-5.

Table IV-1. Forecasting rules for the Bora.

Onset		Rules 1-3
Cessation		Rules 4, 5
Intensity	General	Rules 6-9
	Local Variations	Rules 10-13
Extent		Rules 14-16

Table IV-2. Forecasting rules for the sirocco.

Onset		Rules 17, 18
Intensity	General	Rules 19, 20
	Local Variations	Rule 21
Miscellaneous		Rules 22, 23

Table IV-3. Miscellaneous rules.

Cyclones		Rule 24
Wind	General	Rules 6, 19
	Local	Rules 25, 26
Frontal Activity		Rules 27, 28
Station Reports		Rule 29
Haze		Rules 30-32

Table IV-4. Forecasting rules for ports and anchorages.

Split	Rule 33
Others	Rule 12

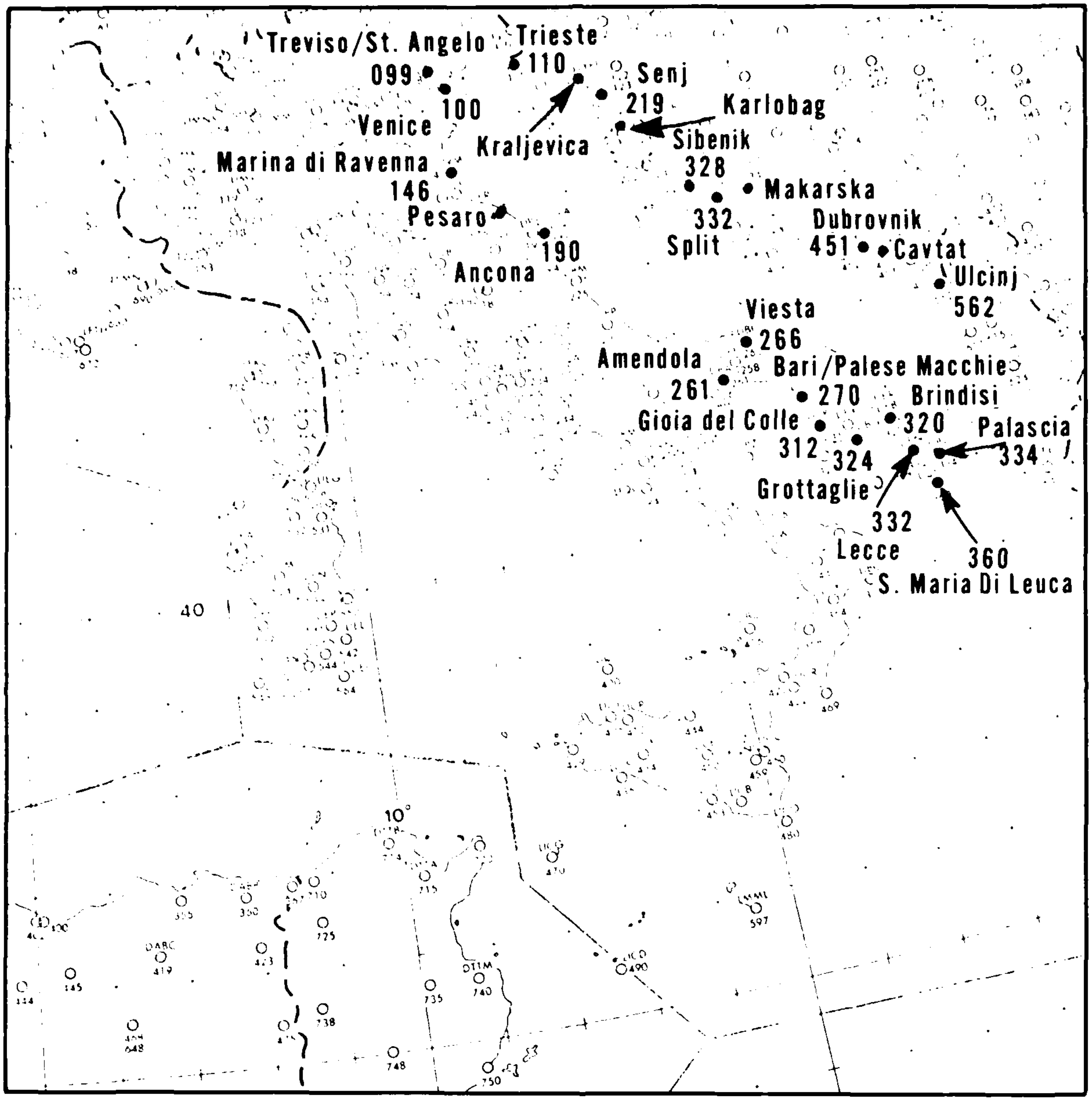


Figure IV-9. Station locator map for the Adriatic Sea Area.

Table IV-5. List of observing stations.

Name of Station	Block No. (Lat.)	Index No. (Long.)
Amendola	16	261
Ancona	16	190
Bari/Palese Macchie	16	270
Brindisi	16	320
Cavtat	42°35'N	18°13'E
Dubrovnik	13	451
Giola Del Colle	16	312
Grottaglie	16	324
Karlobag	44°32'N	15°05'E
Kraljevica	45°18'N	14°36'E
Lecce	16	332
Makarska	43°19'N	17°01'E
Marina di Ravenna	16	146
Palascia	16	334
Pesaro	43°54'N	12°54'E
Senj	13	219
Sibenik	13	328
S. Maria Di Leuca	16	360
Split	13	332
Treviso/St. Angelo	16	099
Trieste	16	110
Ulcinj	13	562
Venice	16	100
Viesta	16	266

BORA, ONSET RULES 1-3

1. Forecast the occurrence of a bora along the Yugoslavian coast when high pressure is predicted to build over the Balkans.

2. Forecast bora conditions to occur in the Adriatic Sea when high pressure is expected to build over the Balkans and a surface low is forecast to move from the Gulf of Genoa southeastward to the northern Ionian Sea.

3. During an extended period of bora conditions, the passage of secondary cold fronts are often associated with sudden wind increases to gale force (33-47 kt).

BORA, CESSATION RULES 4, 5

4. Forecast the end of bora conditions over the Adriatic when high pressure over the Balkans is predicted to weaken or move.

5. The disappearance of the well-defined foehn wall cloud over the Dinaric Alps seen in satellite imagery, and the increase of low clouds over the Adriatic Sea, are indicators of the end of bora conditions.

BORA, INTENSITY RULES 6-13

6. A 10 mb pressure difference -- Treviso/St. Angelo minus S. Maria Di Leuca -- will produce bora winds of 30-35 kt in the Adriatic Sea.

7. During periods of general bora conditions in the Adriatic Sea, the surface wind speeds along the east coast of Italy are quite representative of winds in the western Adriatic Sea. Due to orographic influences, the wind reports at Yugoslavian coastal stations are not representative of winds in the eastern Adriatic Sea.

8. During bora conditions, cumulus cloud streaks seen in satellite imagery indicate gale force winds (33-47 kt).

9. When bora conditions occur in association with a cyclonic weather pattern, the strongest winds will be found in the southern half of the Adriatic Sea.

10. If the direction of the bora at Trieste is east-northeasterly, there will be a well-marked belt of gale force winds reaching the vicinity of Venice with only a 30-40. decrease in velocity. The velocity along the edges of the belt decrease sharply.

11. The following factors locally modify the intensity of the bora:

(1) The greatest intensity of descending flow occurs in areas where the mountain peaks are 2,000 ft or more above sea level.

(2) Mountain passes and ravines aligned with the wind increase the intensity of the bora, as the result of venturi effects.

(3) Bora winds are considerably reduced at the coastline in areas where a coastal plain lies between the foot of the mountains and the edge of the sea.

(4) Sea-breeze effects are likely to decrease the strength of the bora along the eastern shore of the Adriatic Sea between 1100 LT and 1800 LT.

12. Coastal locations (partial list) that experience extremely strong bora conditions are:

(1) Karlobag
(2) Makarska
(3) Dubrovnik
(4) From the Bay of Cattaro (Boka Kotorska) to Ulcinj
(5) Trieste
(6) Split
(7) Sibenik
(8) Kraljevica
(9) Senj

13. Coastal locations that are sheltered from the main effects of the bora include the western coast of the Istria Peninsula, the area to leeward of the islands of Dugi Otok, Kornat and Mljet, and Cavtat.

BORA, EXTENT RULES 14-16

14. The maximum southward extent of bora conditions appears to be about 60 n mi south of the Strait of Otranto.

15. For a bora to extend over the Adriatic Sea long distances from the Yugoslavian coast, an active cyclone is usually required over the southern part of Italy or Ionian Sea.

16. FIBSLP for the Mediterranean area (see Para. 2.1.3 of this section) is capable of descriminating general bora conditions from those bora conditions that are localized along the Yugolavian coast (see Figures IV-4 and IV-6).

SIROCCO, ONSET RULES 17, 18

17. The onset of the sirocco in the Adriatic Sea, unlike the onset of the bora, is usually gradual.

18. Outside of North Africa, the sirocco is almost always associated with depressions that have tight gradients on their eastern sides. The sirocco is especially associated with the North African cyclone

SIROCCO, INTENSITY RULES 19-21

19. A 10 mb pressure difference -- S. Maria Di Leuca minus Treviso/St. Angelo -- will produce sirocco winds of 30-35 kt in the Adriatic Sea.

20. The frequency of gale force sirocco winds (>33 kt) in the Adriatic Sea decreases northward.

21. Diurnal variations of the sirocco at coastal locations can be expected if its direction coincides with that of the sea breeze. Under these conditions, the sirocco -- which is enhanced by the sea breeze during the afternoon -- is apt to subside quickly in the evening.

SIROCCO, MISCELLANEOUS RULES 22, 23

22. The direction of the sirocco tends to be southerly near the entrance to the Adriatic Sea and again off the west coast of Istria. The sirocco tends to be easterly along the northern part of the western shore such as at Marina di Ravenna and Pesaro.

23. During a sirocco in the Adriatic Sea, expect heavy fog north of the island of Palagruza (Pelagosa), especially from October to January.

MISCELLANEOUS, CYCLONES RULE 24

24. Rules 24a and 24b can be used to decide whether a predicted Genoa cyclogenesis will occur in the Gulf of Genoa or to the east in the Gulf of Venice.

24a. If large amounts of cold air penetrate the Po Valley from the north-east, cyclogenesis is expected in the Gulf of Genoa. This cyclone will generally move southeastward along the west coast of Italy.

24b. If little cold air penetrates the Po Valley from the northeast while a strong push occurs in the Gulf of Lion, cyclogenesis will probably take place in the Gulf of Venice. This cyclone may at times move southeast through the Adriatic Sea.

MISCELLANEOUS, WIND RULES 25, 26

25. Strong to gale force winds along the axis of the Strait of Otronto are approximately 40% higher than those registered by the following coastal stations:

(1) Amendola
(2) Viesta
(3) Bari/Palese Macchie
(4) Giola Del Colle
(5) Grottaglie
(6) Brindisi
(7) Lecce
(8) Palascia
(9) S. Maria Di Leuca

26. Wind velocity reported at the island of Palagruza (Pelagosa) is very representative of the wind velocity over the surrounding sea area.

MISCELLANEOUS, FRONTAL ACTIVITY, STATION REPORTS RULES 27-29

27. Shallow cold fronts approaching the Mediterranean basin are greatly retarded by mountain barriers. Deep cold fronts (i.e., those fronts detectable at the 700 mb level) are not hindered by terrain features and sometimes undergo acceleration at the surface. Movement of troughs at the 400 mb level appear to be useful in forecasting this acceleration.

28. Remnants of old cold fronts should be followed very closely in the Mediterranean region. In several cases cyclogenesis has originated along one of these fronts, even after cloudiness associated with these fronts had disappeared. This phenomenon has occurred when an upper level shortwave trough (SD minimum) approached from the west.

29. Hourly observations from Italian coastal stations appears to be somewhat more reliable during daylight hours than at night.

MISCELLANEOUS, HAZE RULES 30-32

30. Salt haze is a serious problem for flight operations over the Mediterranean. This haze has the following characteristics:

(1) It is most prevalent during the summer and early autumn.
(2) Its color is bluish white, as opposed to the brown of dust haze.
(3) Salt haze scatters and reflects light rays much more than does dust haze.

(4) Salt haze sometimes extends to over 12,000 ft and has been reported up to 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi, the slant visibilities for a pilot making a landing approach may be near zero, especially if the approach is in the general direction of the sun.

(6) Salt haze is sometimes thicker aloft than at the surface.

(7) Salt haze is less of a problem after sunset since the poor visibility associated with this phenomenon is caused partially by scattering and reflection of solar rays.

31. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing. It is especially prevalent when there is a strong ridge present at the surface and aloft.

32. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. Visibilities will improve, however, if there is an increase in the wind speeds at the 850 and/or 700 mb levels.

PORTS AND ANCHORAGES, SPLIT RULE 33

33. At the anchorage at Split, Yugoslavia, easterly winds of 20 kt produce seas of 3-4 ft and occasionally up to 7 ft. The fetch is 10 n mi to the east and 30 n mi to the southeast.

V. IONIAN SEA – EAST CENTRAL MEDITERRANEAN AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Ionian Sea - East Central Mediterranean Area* shown in Figure V-1 encompasses the Ionian Sea and the Gulfs of Taranto, Gabes and Sirte (Sidra). Three important sea connections are also included:

(1) The Strait of Otranto connecting the Adriatic Sea with the Ionian Sea (see also Section IV).

(2) The Strait of Messina separating the mainland of Italy from Sicily (see also Section III).

(3) The Strait of Sicily between Sicily and Tunisia (see also Section III).

The most significant topographical features affecting area weather are the Atlas Mountains, located to the southwest of the area. Also exerting important influences are the Apennine Mountains, which are separated from the mountainous island of Sicily by the Strait of Messina (along the northwestern border of the area); the Pindus Mountains; and the mountains of the Peloponnesus along the northeastern border of the area. Such topographical features frequently combine to cause channeling of the air flow, prominent corner effects, or obstacle effects to air flow over mountain barriers.

1.2 SEASONAL WEATHER

The seasonal weather patterns of the Ionian Sea - East Central Mediterranean Area are controlled to a large extent by the monsoonal behavior of both the Eurasia land mass to the north and the Sahara Desert to the south.

During the winter (November through February), high pressure dominates these two land masses while the storm track is found over the relatively warm waters between them; unsettled, windy weather is common. During the summer the land mass to the north is relatively warm while the Sahara is hot in comparison to the water, so weak high pressure with settled, warm, dry weather and light winds is the rule.

---

*Comprises British forecast sea areas Boot, Ionian, Melita, Gabes and Sidra; see Figure 1b in the Introduction.

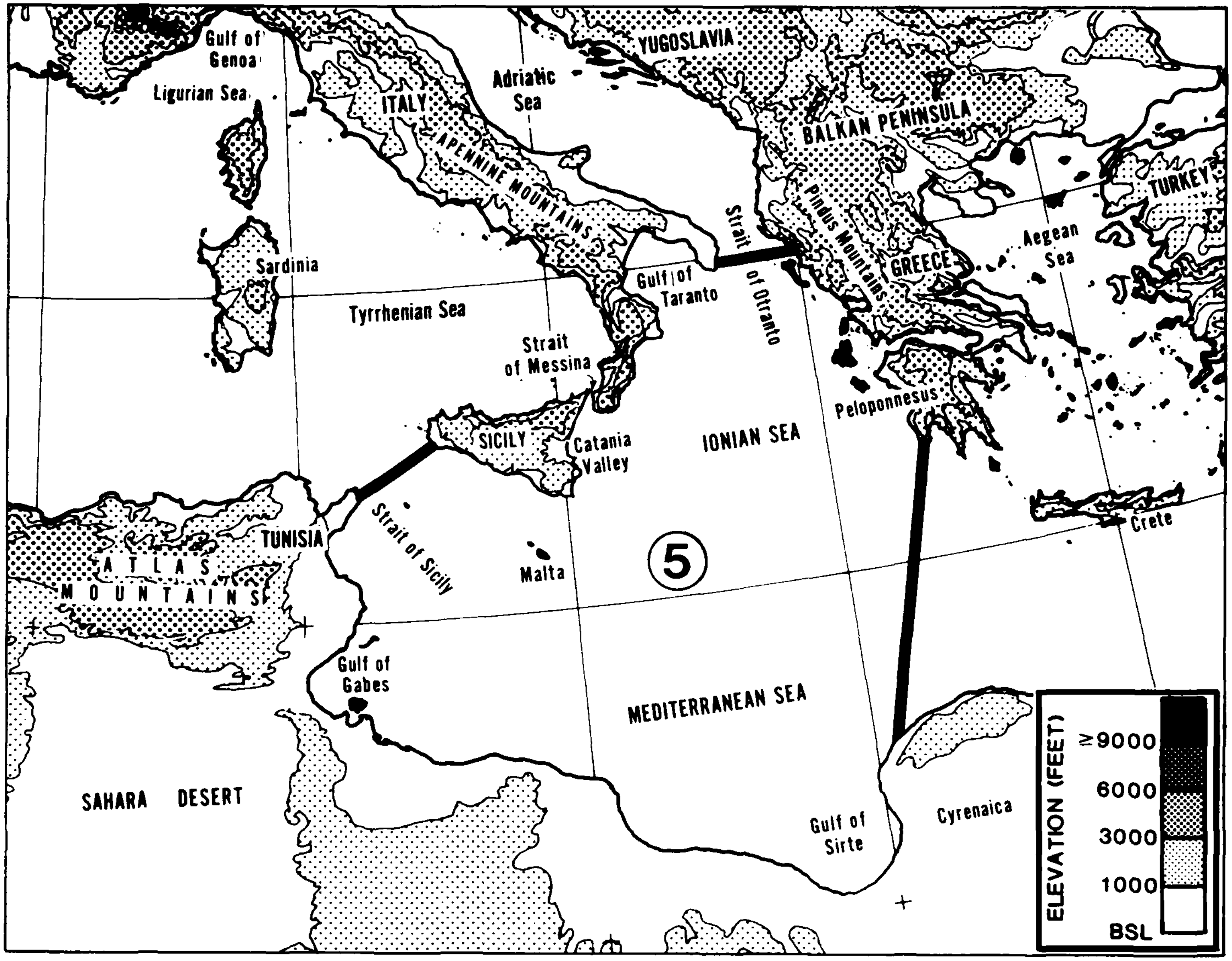


Figure V-1. Topographical map of Ionian Sea - East Central Mediterranean Area.

The transitional seasons, spring and autumn are considerably different in length and character. Spring extends over the relatively long period of March through May and is characterized by the occurrence of North African cyclones that develop over the rapidly heating Sahara. Sirocco conditions are the dominant weather features to the east of these cyclones. Autumn usually lasts only for the month of October and is characterized by an abrupt change from settled summer-type weather to stormy winter-type weather.

2. REGIONAL WEATHER PHENOMENA

2.1 SIROCCO

2.1.1 Introduction

The sirocco is a southeasterly to southwesterly wind over the Mediterranean originating over North Africa. Because the wind originates in the desert, the sirocco is extremely dry initially, warm in winter and hot in spring and summer. Sirocco conditions can occur anywhere over the Mediterranean Basin, but they are most likely to east of the Atlas Mountains in the vicinity of the Gulf of Gabes.

The primary cause of the sirocco is low pressure over the Mediterranean which extends southward over North Africa, resulting in dry air being drawn up from the Sahara Desert. A sirocco therefore can be expected in the following situations (see Figure V-2):

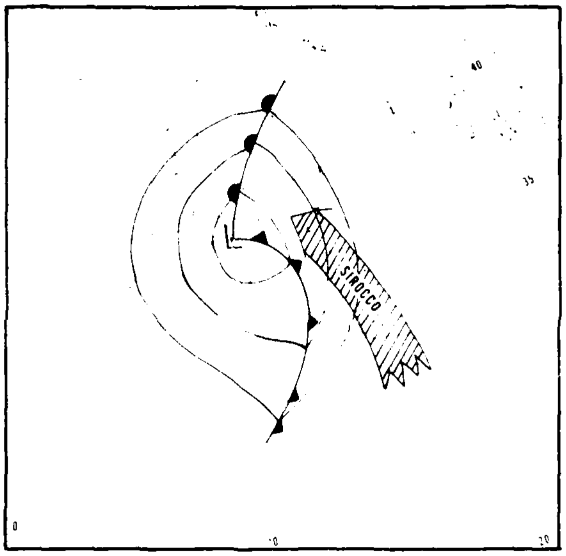
(1) Within the warm sector of North African cyclones. These systems at some time in their life history will draw the necessary dry air up over the Mediterranean from the deserts to the south.

(2) To the east of an inverted trough that extends northward from a cyclone centered well to the south over the North African desert region. This situation is usually confined to near the North African coast.

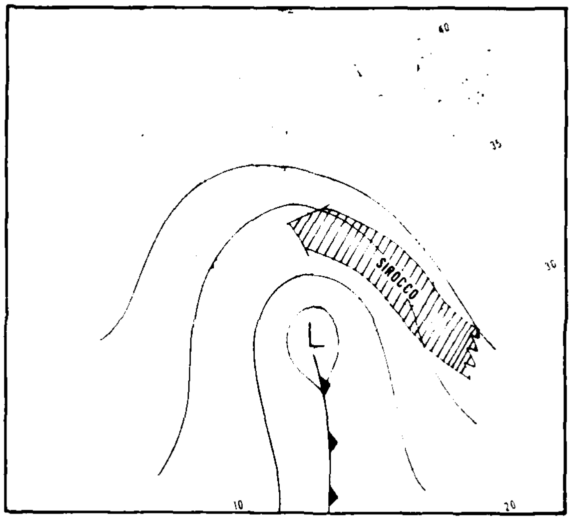
(3) In the warm air ahead of a cold front which extends southward from over the Mediterranean into North Africa.

2.1.2 Climatological Properties

Intensity. Gale force sirocco winds over the water are quite common in the area, especially in the vicinity of the Gulf of Gabes ahead of a developing North African cyclone. Gale force winds are also likely where turbulent mixing causes stronger winds to descend from aloft. This effect can occur both near the North African coast (before the sirocco has been greatly cooled by the relatively cold water surface) and in areas to the lee of mountainous islands such as Sicily.

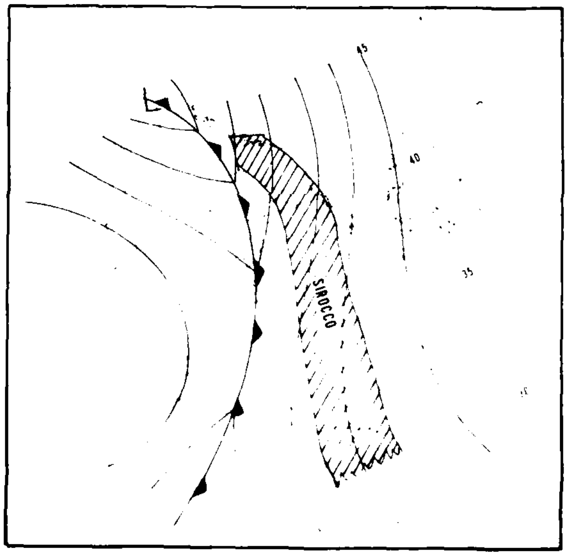


(a) Within the warm sector of a North African cyclone.



(b) To the east of a trough extending northwards from a North African cyclone.

Figure V-2. Synoptic situations associated with sirocco conditions over the Mediterranean Sea.



(c) Within the warm sector of a cyclone north of the Mediterranean Sea.

Direction. The direction of the sirocco is generally from southeasterly to southwesterly. Along the extreme eastern end of the Mediterranean Sea, however, a special occurrence of the sirocco turns the direction to easterly and makes the Arabian desert the source of the air. The sirocco is usually southerly to southeasterly in the Gulf of Genoa, Ligurian Sea, and Adriatic Sea.

Seasonal Variations. The sirocco can occur during any season, although it is most frequent from March through June. During this period, southerly winds of long fetch from the interior of North Africa are common in association with North African cyclones. During late autumn and early winter, when high pressure dominates North Africa, North African cyclones with associated sirocco conditions are less common than during the spring. During the summer, the chances of the sirocco diminish as the mean winds tend to flow inland from the relatively cool sea.

Clouds and Weather. Weather conditions associated with the sirocco depend primarily on the strength of the wind and the length of the overwater trajectory; wind speed and terrain determine the amount of dust present. Dense clouds of dust may reduce visibility to a few yards during a gale force sirocco, especially along the coast of North Africa. Along the coast of Libya, dust conditions can be so severe that they prevent ships from entering the port of Tripoli. Farther to the north, away from the immediate coast, dust still can cause serious problems. At Malta, dust raised over the deserts during the day and carried northward by strong winds has reduced visibility to a few hundred yards during the late afternoon or evening. Even with low wind speeds, dust haze is very common during sirocco conditions.

Although the sirocco begins as a hot, dry wind along the North African coast, air-sea interactions can change the surface properties of the air rapidly. If the air has followed a long overwater trajectory, such as is the case at Malta with light southeasterly winds, patchy low stratus and sea fog are common. Farther north, especially when it meets topographical barriers, such a trajectory would produce extensive low stratus, fog and drizzle, with resultant poor visibilities.

Extremely anomalous radar and radio propagations are likely because of the strong surface inversion produced over the water, especially during the spring. Helicopters are liable to be out of radio contact at a range of 1-2 n mi.

2.2 MISTRAL

The mistral is a cold, strong, northwesterly to north-northeasterly wind that flows offshore along the coast of the Gulf of Lion (see Section II, Para. 2.1), at times extending far beyond the Gulf of Lion to affect the Ionian Sea - East Central Mediterranean Area. Within this latter area, the extension of the mistral is likely to be most intense due to channeling effects downwind from the Strait of Sicily toward Malta.

The occurrence of gale force mistral winds at this great distance from the Gulf of Lion is closely related to the upper-level large-scale flow pattern and the development and movement of the Genoa cyclone (see Para. 2.5.2). The particular upper-level (500 mb) flow pattern associated with the southeastward extension of the mistral into the Malta area, is one in which there is a blocking ridge in the eastern Atlantic and a long-wave trough over Europe (see Figure III-2). A strong northwesterly jet associated with this flow pattern extends southeastward from western France.

Since the mistral is characterized by the sinking and spreading out of cold air along the coast of southern France, low clouds are usually not observed over the Gulf of Lion (reference Figure II-7, Section II). The considerable convective cloudiness seen in Figure II-7, a satellite image from the Strait of Sicily eastward, is the result of the cold air being modified by the long trajectory over relatively warm water.

2.3 BORA

The bora is a strong, cold, downslope wind. Its source is so cold that when the air reaches the coast, the dynamic warming is insufficient to raise the air temperature to the normal level for the region (see Section IV, Para. 2.1). Although it is most common along the coast of Yugoslavia, the bora can extend to the Ionian Sea - East Mediterranean region. The bora tends to emerge through the Strait of Otranto in a narrow band of strong winds directed toward the northwest coast of Libya. These conditions usually occur only during the winter after an intense cyclone has moved eastward across the Ionian Sea (see Figure V-3).

Weather associated with the bora depends on the distance the cold air has traveled over water. Along the west coast of Greece, skies are clear and visibilities excellent. Farther downstream, convective type cloudiness is more common. If a depression develops in the south central Mediterranean during the bora or gregale (see below), conditions deteriorate rapidly and low clouds, heavy rain and poor visibilities are likely. Seas of up to 20 ft have also been experienced at Malta during such cases.

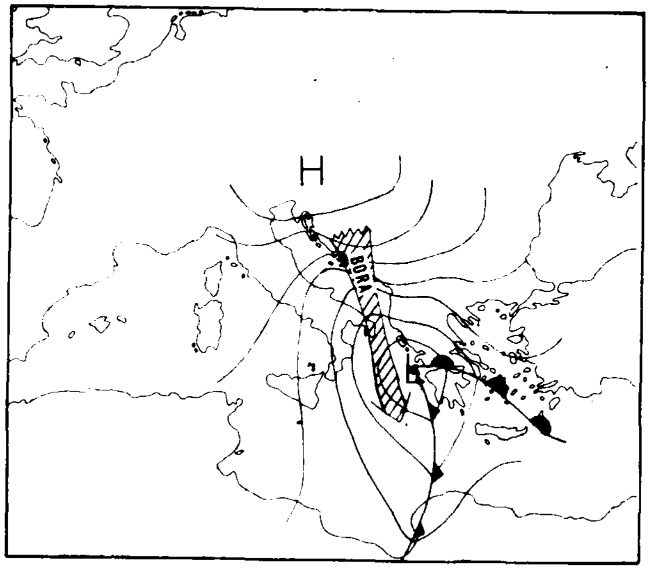


Figure V-3. Synoptic situation associated with a bora extending southward through the Strait of Otranto.

2.4 GREGALE

The gregale is a strong, northeasterly wind in the Ionian Sea - East Central Mediterranean Area that occurs in situations similar to those which produce the bora: an intense anticyclone over Central Europe and the Balkans, with low pressure to the south (see Figure V-4). During these periods, which occur mostly in winter, the bora/gregale extends from the Adriatic Sea to Malta. It is only along the west coast of Greece, however, that the air has the cold, dry properties associated with the bora.

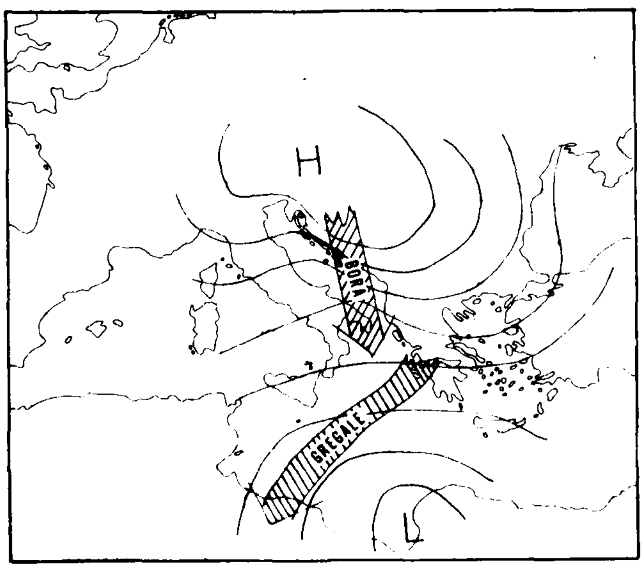


Figure V-4. Synoptic situation associated with both a bora over the Adriatic Sea and a gregale over the Ionian Sea-East Central Mediterranean Area.

2.5 CYCLONE OCCURRENCES

2.5.1 North African Cyclones

North African cyclones are low pressure systems which, during their incipient stages, are found south of the Atlas Mountains. These cyclones are sometimes referred to as either Sahara depressions or Atlas lee depressions.

Factors Associated with Development. Several factors have special importance in the development of North African cyclones:

(1) The large-scale flow pattern, which produces a deep southwesterly flow over northwest Africa.

(2) A moving upper-level shortwave trough (SD minimum). Without the vorticity advection associated with this feature, the North African cyclone is not likely to deepen as it moves out of the generating area.

(3) Interaction between the polar front jet and the subtropical jet.

(4) The Atlas Mountains, which act as a barrier to lower tropospheric air from the north. The effect of this blocking action normally prevents rapid cyclogenesis until the incipient low reaches the Gulf of Gabes, east of the mountain barrier.

Climatology of Development. Cyclogenesis south of the Atlas Mountains is most likely during the spring and least likely during the summer. The average frequency is 14 cases per year, or about 20% of the annual total of Mediterranean cyclogenesis. An average of eight cases of cyclogenesis south of the Atlas Mountains can be expected during the spring (March through May).

Although initial development occurs anywhere south of the Atlas Mountains, rapid cyclogenesis is usually delayed until the depression reaches the east coast of Tunisia and the Gulf of Gabes, east of the mountain barrier.

Cyclogenesis over the water, north of the Atlas Mountains, occasionally occurs in association with a North African cyclone (as shown in Figure II-12, Section II). This secondary system is likely when strong upper-level southwesterlies are present across the Atlas Mountains. Although the secondary low can be quite intense, it usually decays as soon as the parent low reaches the Gulf of Gabes.

Cyclone Movement. North African cyclones generally move eastward south of the Atlas Mountains before entering the Mediterranean Basin, although cases of intense depressions moving northward into the Mediterranean through the Biskra gap are well documented. The typical tracks of these depressions are shown in Figure V-5a, which indicates that the majority of the cyclones move northeastward across the Ionian Sea - East Central Mediterranean Area. The centers that move eastward south of the coast usually remain quite weak; however, they must be watched closely for signs of northeastward movement toward either the Crete or Cyprus areas where rapid intensification may occur.

Associated Weather Phenomena. The sirocco is the primary weather phenomenon associated with the North African cyclone. The sirocco occurs ahead of most of these depressions and is strongest and most persistent in the Gulf of Gabes/Strait of Sicily area before the North African low moves out over the Mediterranean.

Shower and thundershower activity with poor visibilities are most common during autumn and early winter when sea surface temperatures are warm. In the spring, although rain and cloudiness still occur, shower activity is somewhat less because of the relatively cool sea surface temperature.

2.5.2 Genoa Cyclones

Genoa cyclones (described in Section III, Para. 2.3.1) develop in the area to the south of the Alps which includes the Gulf of Genoa, Ligurian Sea, Po Valley, and northern Adriatic Sea. These depressions affect the Ionian Sea - East Central Mediterranean Area when they move in a southeasterly direction near the northern border of the Mediterranean Sea (see Figure V-5b). This occurs in association with a strong anticyclone over the Balkans, Turkey and the Black Sea. It is a common occurrence for the parent low to become stationary just to the west of southern Italy. If this happens, a new center will usually develop to the east over the Ionian Sea.

Weather phenomena associated with the Genoa cyclone are the mistral, bora/gregale and sirocco. Also in association with a strong bora in the Adriatic Sea, the depression is likely to become extremely intense upon entering the Ionian Sea and thus cause gale force winds over the entire Ionian Sea - East Central Mediterranean Area.

2.5.3 Ionian Sea Cyclones

Most cyclones found in the Ionian Sea that are not associated with North African cyclones are depressions that have either moved southeastward from the Gulf of Genoa or developed in association with a Genoa cyclone stalled near Southern Italy. Cyclones do develop over the northern Ionian Sea, however, in association with an invasion of cold air moving southward from the Adriatic Sea. These systems may move southward or even southwestward at first, before moving eastward towards Crete (see Figure V-5b).

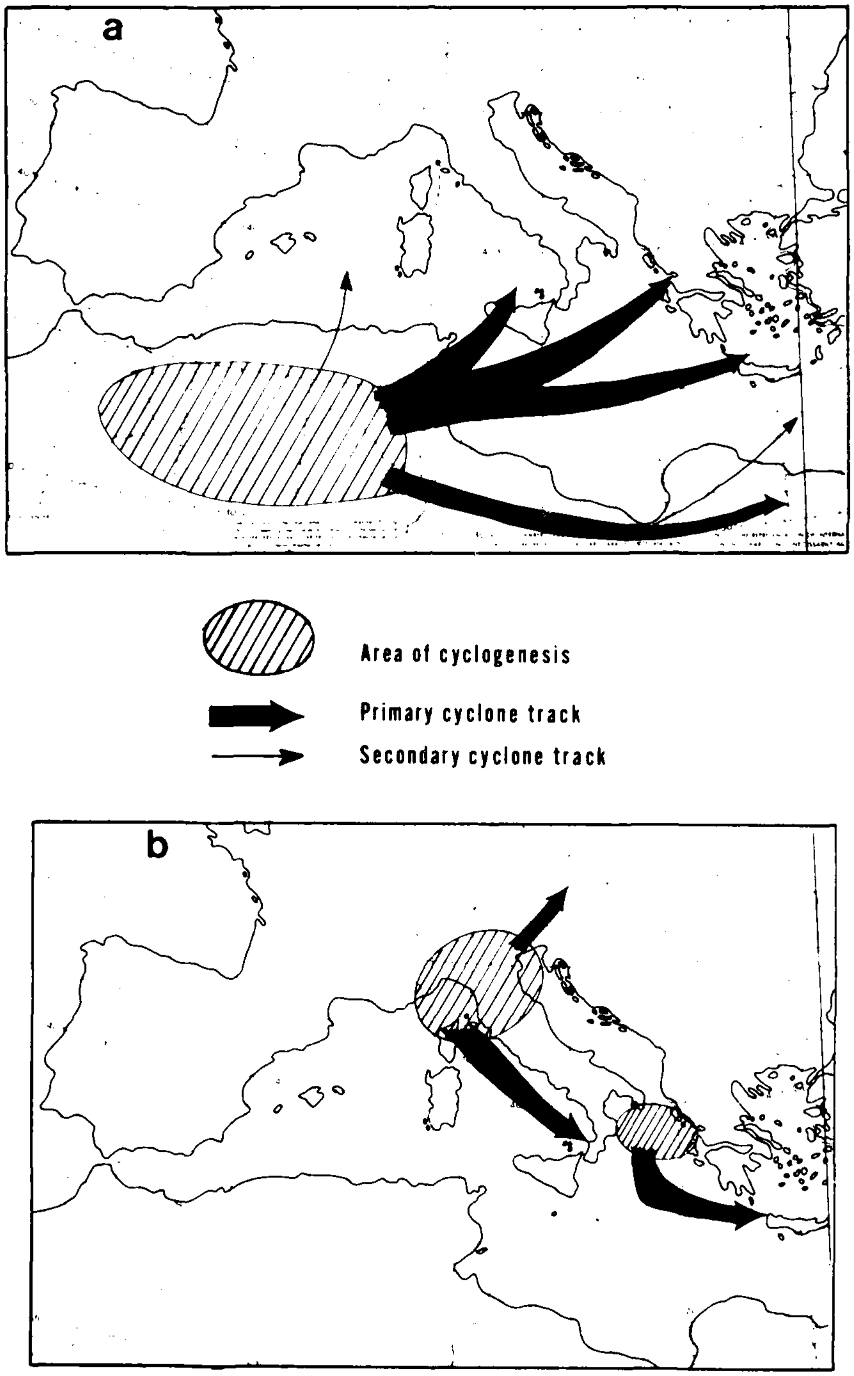


Figure V-5. Areas of cyclogenesis and tracks of cyclones which affect the Ionian Sea - East Central Mediterranean Area: (a) North African cyclones; (b) Genoa cyclones and Ionian Sea cyclones.

Weather phenomena associated with the Ionian Sea cyclone in the Ionian Sea - East Central Mediterranean Area are similar to those described for Genoa cyclones in Para. 2.5.2 of this section.

3. FORECASTING RULES

Tables V-1 through V-4 provide quick reference to the 49 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location within the area of interest. Observing stations locations are shown in Figure V-6, and listed in Table V-5.

Table V-1. Forecasting rules for the sirocco.

Onset		Rules 1-3
Intensity	General	Rule 4
	Local Variations	Rules 5, 6
	Turbulence	Rules 7, 8
Significant Weather	Radar/Radio Propagation	Rule 9
	Other	Rule 10

Table V-2. Forecasting rules associated with North African cyclones.

Cyclogenesis		Rules 11-13
Movement	Numerical Products	Rules 14, 15
	Other	Rules 16, 17
Surface Winds		Rules 18-20
Haze		Rule 21

Table V-3. Miscellaneous forecast rules.

Mistral		Rules 22, 23
Bora		Rules 24, 25
Frontal Activity		Rules 26-29
Local Winds	Strait of Otranto	Rule 30
	Strait of Messina	Rules 31, 32
	Strait of Sicily	Rule 33
Cyclone Movement		Rule 34
Precipitation		Rule 35
Haze		Rules 21, 36-38

Table V-4. Forecasting rules for stations and anchorages.

Sigonella	Rules 39-42
Valletta	Rules 43-45
Taranto	Rules 46-48
Argostolion	Rule 49

Table V-5. List of observing stations.

Name of Station	Block No. (Lat,	Index No. Long)
Amendola	16	261
Argostolion Bay	16	685
Bari/Palese Macchie	16	270
Biskra	60	525
Brindisi	16	320
Cazzo Spadaro	16	480
Djelfa	60	535
El Qued-Guemar	60	559
Gela	16	453
Gioia Del Colle	16	312
Grottaglie	16	342
Lampedusa	16	490
Lecce	16	332
Luga/Valletta	16	597
Messina	16	420
Palascia	16	334
Pantelleria	16	470
Quargle	60	580
Sigonella	16	459
S. Maria Di Leuca	16	360
Taranto	40°28'N	17°15'E
Tripoli	62	010
Viesta	16	266

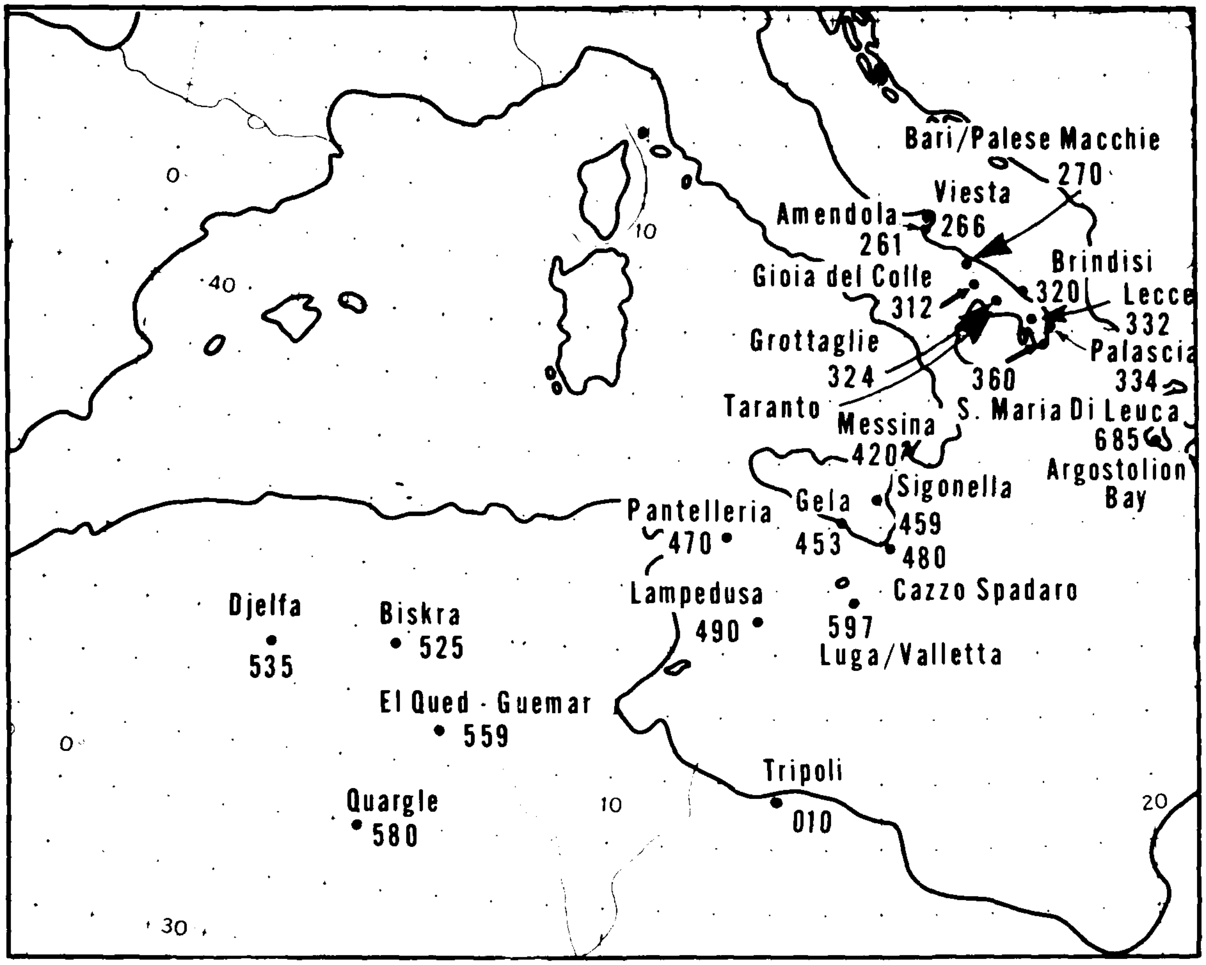


Figure V-6. Station locator map for the Ionian Sea - East Central Mediterranean Area.

SIROCCO, ONSET RULES 1-3

1. Forecast a strong sirocco if two conditions are met: (1) an upper trough is present over the Balkans with a strong jet stream along its southern boundary; and (2) large pressure falls (after the diurnal pressure is removed) are observed at stations along the east coast of Tunisia.

2. Increasing southerly winds at coastal stations along the northeast coast of Libya indicate the start of a sirocco.

3. Outside of North Africa, the sirocco is almost always associated with depressions and blows on the eastern side. The sirocco is especially associated with the North African cyclone.

SIROCCO, INTENSITY RULES 4-6

4. During a sirocco, dense belts of altocumulus castellanus approaching from the southwest -- probably associated with weak upper-level troughs -- are at times associated with radical and sudden changes in both the direction and speed of the wind.

5. Large variations in both wind and temperature are experienced during the sirocco in the lee of islands that have hilly terrain. These effects are the result of turbulent mixing of the surface inversion on the downwind side of the islands.

6. Sirocco conditions crossing the Island of Sicily produce strong and gusty foehn-type winds on the north and east sides of this island, most evident at the entrance to the Catania Valley. It has been noted that during these conditions, ships experience better weather conditions south of Sicily than north of the island. Sea conditions, on the other hand, would be better north of Sicily due to the small fetch.

SIROCCO, SIGNIFICANT WEATHER RULES 7-10

7. During periods of sirocco over the Mediterranean, a low-level jet is likely to be found just below the top of the very marked temperature inversion common during these conditions. Wind speeds reaching 70 to 80 kt with heavy turbulence associated with the strong vertical wind shear, have been observed in this jet.

8. A good indication of turbulence above the surface inversion during a sirocco is the violent "pumping" seen from barograph traces.

9. The surface inversion that occurs over the relatively cool water during the spring sirocco causes extremely anomalous radar and radio propagations in the dust-laden atmosphere below the inversion; helicopters are liable to be out of radio contact at a range of 1-2 n mi.

10. Weather associated with the sirocco is largely dependent on both the length of the wind's overwater trajectory and the wind speed. High wind speeds and short overwater trajectories produce large amounts of dust that reduce visibilities, while low wind speeds and long overwater trajectories produce high humidities with fog and poor visibilities.

NORTH AFRICAN CYCLONES, CYCLOGENESIS RULES 11-13

11. The North African cyclone is most likely to intensify over Tunisia when:

(1) The axis of a long-wave trough is oriented northeast-southwest across the Tyrrhenian Sea.

(2) A cold pocket of air aloft (-25°C at 500 mb) is located between Sardinia, Sicily and Tunisia.

(3) Southwesterly winds at 500 mb over Tunisia and Libya are 55 kt or more.

(4) The subtropical jet is evident over North Africa.

(5) Cold polar air at the surface is being advected over the Mediterranean from eastern Europe.

12. An indication of possible North African cyclogenesis in spring and early autumn are the pressure tendencies at Biskra, Djelfa, El Qued-Guemar, and Quargle. If all of these stations show strong pressure falls over a 6 hr period, cyclogenesis can be expected to occur within the next 24 hr.

13. A small-scale "shadow" low appearing along the northern Algerian coast, in association with a developing North African low, can sometimes become the dominant low in the Strait of Sicily. (An example is shown in Figure II-12, Section II.)

NORTH AFRICAN CYCLONES, MOVEMENT RULES 14-17

14. The sea-level pressure analysis scheme (FIBSLP) for the Mediterranean area, produced by FNOC (Catalog No. A-04), is a useful tool in detecting/observing the formation and movement of the North African cyclone in the vicinity of Tunisia.

15. It has been observed that numerical models tend to move developing North African lows northeastward across the Atlas mountains. The correct course is usually first to the east, south of the Atlas Mountains, and then northeastward across the Gulf of Gabes.

16. A good indication that a North African cyclone will begin to move northeastward out over the Mediterranean is an increase of middle cloudiness ahead of the system.

17. During the spring, North African cyclones that have moved out over the Mediterranean will generally track toward the northeast if the heat trough over Turkey is deeper than 1000 mb. If a surface high or only a weak low is present over Turkey, however, North African cyclones can be expected to become stationary over the Ionian Sea about 75% of the time.

NORTH AFRICAN CYCLONES, SURFACE WINDS, RULES 18-20

18. The strongest winds associated with deepening North African cyclones, after these systems move out over the Mediterranean, occur in the northwest sector of these systems rather than in the eastern sector.

19. Forecast the maximum strength of surface winds to occur in the northwest section of a North African cyclone, when a pool of cold air aloft arrives (as shown in Figure III-6, Section III).

20. When North African lows occur south of the Atlas Mountains, strong easterly to southeasterly winds are likely over the southern Mediterranean. These winds cause high seas in the Strait of Sicily.

NORTH AFRICAN CYCLONES, HAZE, RULE 21

21. Haze is common over the Ionian Sea. The haze tends to be worst during periods of southerly winds that are preceding North African cyclones moving northeastward out of Tunisia.

MISCELLANEOUS FORECAST RULES, MISTRAL, BORA RULES 22-25

22. Strong mistral winds occur on the cyclonic side and underneath the polar front jet axis. The mistral will extend as far southeastward as the upper trough and jet, so the mistral occasionally extends southeastward through the Strait of Sicily to Malta.

23. During a mistral situation, wave clouds visible on satellite imagery as extending from Sardinia to Sicily are generally indicative of a gale force mistral that extends southeastward into the Strait of Sicily.

24. When the bora emerges through the Strait of Otranto, it is visible on satellite imagery as a narrow stream directed towards northwest Cyrenaica. This narrow belt of strong winds, like the mistral, has been observed by aircraft to extend up to 10,000 ft.

25. The maximum southward extent of bora conditions originating over the Adriatic Sea appears to be about 60 n mi south of the Strait of Otranto.

MISCELLANEOUS FORECAST RULES, FRONTAL ACTIVITIES RULES 26-29

26. Shallow cold fronts approaching the Mediterranean Basin are greatly retarded by the mountain barriers. Deep cold fronts (i.e., those fronts detectable at the 700 mb level) are not hindered by terrain features and occasionally undergo acceleration at the surface. Movement of troughs at the 400 mb level appears to be useful in forecasting this acceleration.

27. Remnants of old cold fronts should be followed closely. In several cases cyclogenesis has originated along one of these fronts, even after cloudiness associated with these fronts had disappeared. This phenomenon has occurred when an upper level shortwave trough (SD minimum) approached from the west.

28. Cold fronts approaching the central Mediterranean become very active when they slow down. Multiple low centers with heavy rain are very common. This pattern remains stationary until the upper trough either moves eastward or fills.

29. Very useful "upstream" stations for indications of fronts approaching the Malta area from the northwest are Cazzo Spadaro, Gela, Pantelleria, and Lampedusa. The latter two stations are considered the most useful.

MISCELLANEOUS FORECAST RULES, LOCAL WINDS RULES 30-33

30. Strong to gale force winds ($\geq$22 kt) along the axis of the Strait of Otranto are approximately 40% higher than those registered by the coastal stations at Amendola, Viesta, Bari/Palese Macchie, Gioia Del Colle, Grottaglie, Brindisi, Lecce, Palascia, and S. Maria Di Leuca.

31. Winds with a north or south component are funneled through the Strait of Messina and fan out in a "V" on the downwind side. Rough seas are experienced on each side of the "V."

32. The surface wind report at Messina is not representative of winds in the Strait of Messina. Southwesterly gales, common events in the Strait, are not indicated by the wind at Messina.

33. The wind report at Pantelleria is very representative of the surface winds in the Strait of Sicily.

MISCELLANEOUS FORECAST RULES, CYCLONE MOVEMENT, PRECIPITATION RULES 34-35

34. Surface lows moving southeastward through the Tyrrhenian Sea appear to fill when they reach the southwest tip of Italy. When this occurs, a new center usually develops to the east over the Ionian Sea; thus, the center appears to move discontinuously across the land mass of Italy. The same effect is observed when a surface low crossing the Ionian Sea reaches Greece with the old center filling and a new center developing in the Aegean Sea.

35. During periods of general southerly surface flow in the central Mediterranean, convergence zones between southeasterly and southwesterly winds are frequently observed. These convergence zones are regions of heavier precipitation and lower visibilities. Fronts are not initially associated with this phenomenon, but they may develop later.

MISCELLANEOUS, HAZE RULES 36-38

36. Salt haze is a serious problem for flight operations over the Mediterranean. This haze has the following characteristics:

(1) It is most prevalent during the summer and early autumn.

(2) Its color is bluish white, as opposed to the brown of dust haze.

(3) Salt haze scatters and reflects light rays much more than does dust haze.

(4) Salt haze sometimes extends to over 12,000 ft and has been reported up to 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi the slant visibilities for a pilot making a landing approach may be near zero, especially if the approach is in the general direction of the sun.

(6) Salt haze is sometimes thicker aloft than at the surface.

(7) Salt haze is less of a problem after sunset since the poor visibility is caused partially by scattering and reflection.

37. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing. It is especially prevalent when there is a strong ridge present at the surface and aloft.

38. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. Visibilities will improve, however, if there is an increase in the wind speeds at the 850 and/or 700 mb levels.

STATIONS AND ANCHORAGES, SIGONELLA RULES 39-42

39. Turbulence is a severe problem at Sigonella. Winds west-northwesterly through northerly at at least 30 kt (measured at 10,000 ft) will cause significant turbulence from near the surface to about 20,000 ft.

40. Poor visibilities caused by low cloudiness, rain or drizzle can be anticipated at Sigonella during late autumns, winter and spring in advance of a low pressure system that causes air to flow into the Catania Valley from the east or southeast.

41. The easterly sea breeze that occurs daily at Sigonella after mid-June generally starts between 1000 LT and 1030 LT and averages 10-15 kt gusting to 18 kt until weakening after 1800 LT.

(1) With a 2-5 kt westerly wind flow over water areas surrounding Sicily, anticipate a 1/2 to 1 hr delay in the starting time of the sea breeze.

(2) With a weak cold front extending into the western Mediterranean Basin during the early morning, anticipate an increase in the westerly flow in advance of the front and retardation of starting time of the sea breeze. There is also a distinct possibility that the sea breeze will not reach Sigonella.

(3) With a 2-5 kt easterly wind flow over water areas surrounding Sicily, anticipate an invasion of the sea breeze up to 1/2 to 1 hr early.

42. Expect showers and thundershowers to occur at Sigonella during the summer and autumn when:

(1) There is low level easterly moist air flow into the Catania Valley.

(2) There are westerly winds aloft. Under these wind conditions, the convective activity will form along the mountains to the west and northwest of Sigonella and drift eastward after formation.

STATIONS AND ANCHORAGES, VALLETTA RULES 43-45

43. The carrier anchorage off Valletta, Malta, experiences high seas during gregale (strong northeasterly) wind conditions. With lows existing over northwest Africa, common in winter and spring, east to northeasterly winds often reaching 20-30 kt for extended periods can produce seas in excess of 12 ft.

44. The carrier anchorage off Valletta, Malta, experiences much stronger northwesterly winds than occur at Luga. There have been cases in which strong northwesterly winds and high seas following a frontal passage have cancelled boating for several days at the anchorage; winds of 30 kt have occurred at the anchorage while winds at Luga were only 15 kt.

45. The carrier anchorage at Valletta, Malta, offers limited protection from winds in the southwest quadrant and none from the other directions. During mistral conditions, winds averaging 25-35 kt with gusts to 50 kt are not uncommon. Wind speeds at Luga are about half as strong.

STATIONS AND ANCHORAGES, TARANTO, ARGOSTOLION RULES 46-49

46. Taranto, Italy, offers one of the few Mediterranean anchorages where weather is not greatly affected by the surrounding terrain. The terrain at Taranto is low and flat to the north and east, and the fetch is uninterrupted for 25 n mi to the southwest.

47. Forecast fog at Taranto, Italy, if there is a light offshore wind (approximately 5 kt) during the evening, the relative humidity is ≥ 90, and the sea surface temperature is at least 2°C warmer than the air temperature.

48. Visibility at Taranto, Italy, is generally restricted because of heavy industrial smoke.

49. The anchorage in Argostolion Bay is one of the most hazardous moorings in the Mediterranean. Seas usually do not build in Argostolion, but extremely variable winds associated with the local topography, up to 40-50 kt, can come up without warning.

VI. CRETE – AEGEAN SEA AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Crete-Aegean Sea Area* shown in Figure VI-1 encompasses the Aegean Sea, Cretan Sea, and Mirtoan Sea. Also included is the Dardanelles which, together with the Sea of Marmara and the Bosporus, form the sea connection to the Black Sea.

This area is surrounded on three sides by complex topographical features. To the west are the Pindus Mountains of Greece, which are separated from the mountains of the Peloponnesus by the Gulf of Corinth. To the east are the Alacam Dagari and Boz Daglar of western Turkey. To the north are the Rhodope Mountains; this range is separated by the Vardar gap from the Pindus Mountains of Greece, and by the Dardanelles gap from the mountains of Turkey. On the southern edge of the Crete-Aegean Sea area is the mountainous island of Crete. The sea area is dotted by numerous islands which further complicate the area topography.

These topographical features frequently combine to create channeling of the air flow by both the coastal valleys and the channels between islands, prominent corner effects, and/or obstacle effects to air flow over the various mountain barriers.

1.2 SEASONAL WEATHER

The seasonal weather patterns of the Crete-Aegean Sea Area are controlled to a degree by the monsoonal character of the Eurasian land mass. During the winter season (November through February), the land mass to the north is very cold in comparison to the sea surface of the Mediterranean Sea. With the upper-level westerlies often found over the Mediterranean, cyclonic activity with unsettled weather is common in the area. Because of the proximity of cold air to the north, cold outbreaks are frequent winter events.

---

*Comprises British forecast sea areas Aegean and Jason; see Figure 1b in the Introduction.

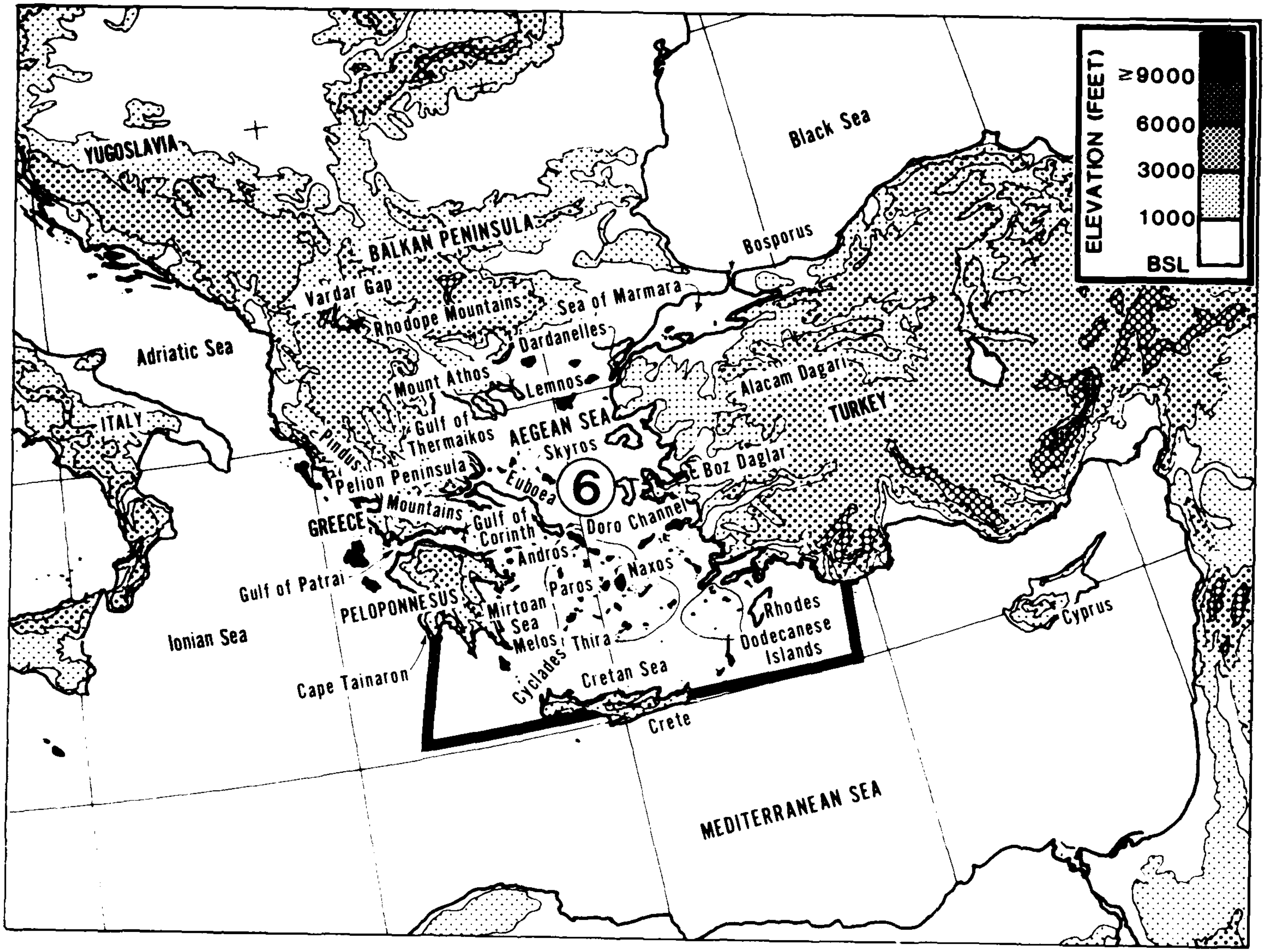


Figure VI-1. Topographical map of Crete-Aegean Sea Area.

During the summer season (June through September), the monsoonal effect leads to the development of an intense heat trough over southern Asia that extends westward over Turkey. With higher pressure over the relatively cooler sea surface of the Mediterranean, dry northerly to northwesterly flow dominates the Crete-Aegean Sea Area. This wind regime, the etesian, is described in Para. 2.1.

The transitional seasons, spring and autumn, are of very different length. The relatively long spring season (March through May) is noted for periods of stormy winter-type weather that alternate with a number of false starts of the etesian-type weather of summer. Autumn lasts only about one month (October), and is characterized by an abrupt change to winter-type weather. Cold outbreaks become more frequent in autumn as the land mass to the north cools, and cyclonic activity increases as the upper-level westerlies move southward over the relatively warm waters of the Mediterranean.

2. REGIONAL WEATHER PHENOMENA

2.1 ETESIAN

2.1.1 Introduction

The etesian is a northerly wind that occurs during the summer in the Aegean Sea and eastern Mediterranean. The prevailing period for the etesian ("melten" in Turkish) is May through October; maximum frequency and strength occur in July and August.

The etesian results from a combination of the following:

(1) The monsoonal effect during the summer that leads to a low pressure trough over Turkey with higher pressure over the adjacent water surface.

(2) Synoptic disturbances that lead to anticyclogenesis over the Balkans. Cold air in the anticyclone following frontal passages appears to be the main cause of gale force etesians.

(3) A jet-effect wind increase caused by channeling of the air between islands. This is most apparent in the Doro Channel between the islands of Euboea and Andros, in the channel between the mainland of Turkey and the Dodecanese Islands, and in the area between Paros and Naxos as far south as Thira.

(4) Mountains oriented perpendicular to the etesian which, under strong inversion conditions, block the flow and give calm seas in the lee. Strong winds are usually found only offshore from coastal valleys, an effect common on the south side of Crete.

2.1.2 Climatological Properties

Extent. The etesian extends from the Aegean Sea southeastward into the eastern Mediterranean. The maximum wind axis (see Figure VI-2) begins in the northeast Aegean Sea, passes slightly east of Lemnos and Skyros through the Cyclades, passes through the opening between Rhodes and Crete, and ends in the southeast Mediterranean with reduced force. A secondary maximum wind axis also shown in Figure VI-2, is found off the southwest coast of the Peloponnese.

Direction. The wind direction of the etesian generally coincides with the maximum speed axis, so the northerly winds in the Aegean Sea become westerly over the eastern Mediterranean.

Strength. Along the primary axis of maximum wind shown in Figure VI-2, etesian wind speeds greater than 33 kt occur about 10% of the time over the southern Aegean Sea. Gale force etesians occur infrequently in other areas except in those locations where channeling and/or sea breeze effects combine to increase wind speeds.

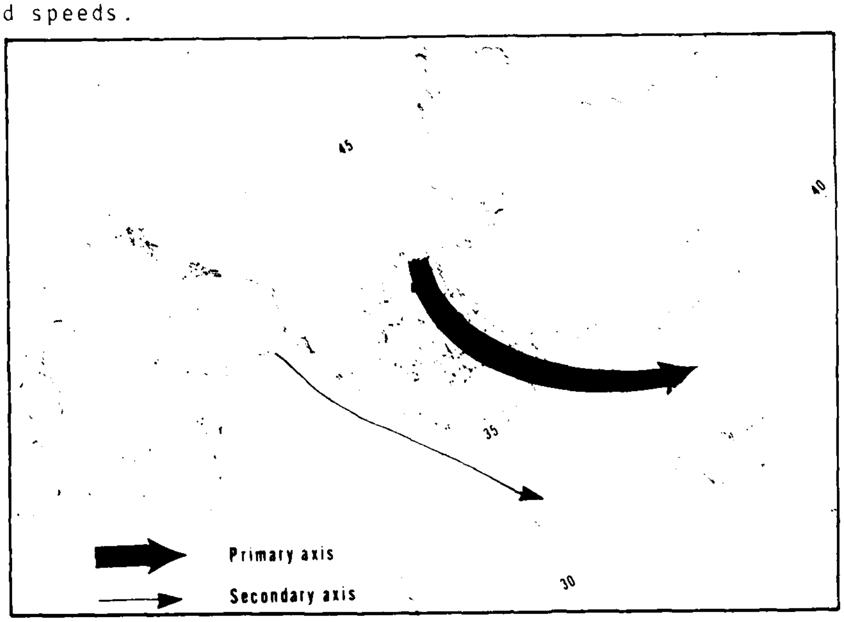


Figure VI-2. Axes of maximum wind associated with the etesian.

Frequency and Duration. The frequency of occurrence of days during which etesian conditions are capable of producing gale force winds over the open water is variable. On the average, there will be about four such days during May, a maximum of 13 days during July and August, and six days during October. The standard deviation of the number of etesian days occurring during a given month is large, varying from about three days in May to four days in August; thus the probability that an etesian will occur during any given May or June is relatively low.

The mean length of a gale force etesian spell varies from about two days in May and June to a maximum of about four days in July and August and back to two days in October. During July and August it is quite likely that the etesian will last at least five days and occur on the average of once a month. An etesian that lasts at least ten days can be expected about once in six years during each of the months of July through September.

Diurnal Variation. Coastal stations show a large diurnal variation due to sea breeze effects. Along the west coast of Greece (including the islands in the Ionian Sea) where the etesian is relatively weak, winds at night are almost completely calm, becoming westerly to northwesterly 10-20 kt by noon, and increasing locally to 25 kt during the afternoon.

Along the east coast, the sea breeze strength is difficult to estimate due to the lack of stations. At Athens, where the sea breeze opposes the etesian, the frequency of northerly winds drops to its minimum near noon as the sea breeze decreases the effect of the etesian.

Over the open Aegean Sea, available data show little variation in the etesian in the north where the maximum wind speed occurs before 1400 LT at Lemnos. Over the southern Aegean Sea there is a larger variation, however, with peak wind speeds at Naxos between 1400 LT and 1700 LT and gale force winds likely.

Clouds and Weather. Etesian weather is generally dry with clear skies and good visibilities. When a synoptic scale disturbance and associated cold front initiates the etesian, however, thunderstorms frequently occur over the northern Aegean Sea both ahead of the front and in the cold unstable air immediately behind the front. This is especially true for the months of May-June and September-October, but less so for July and August. Scattered clouds, mostly altocumulus, precede the start of a strong etesian during July and August. Orographic clouds can form over some of the islands in the Aegean Sea during a strong etesian.

2.2 BORA

The bora is a fall wind whose source is so cold that when the air reaches the coast, the dynamic warming is insufficient to raise the air temperatures to the normal level for the region. Although it is most common along the Yugoslavia coast (see Section IV, Para 2.1) the bora often can occur in the Aegean Sea, mainly during the winter.

In the Crete-Aegean Sea Area, the bora is a strong northerly to northeasterly wind that comes over the Aegean Sea through the Dardanelles and Vardar gaps. If the pressure distribution favors a northeasterly wind, the main entrance for the bora is the Dardanelles gap. If the pressure distribution favors northerly flow, the main entry is through the Vardar gap.

As the bora flows southward over the Aegean Sea, its direction changes to northwesterly by the time it reaches the Dodecanese Islands. Because of channeling, obstacle and corner effects, however, large variations of both direction and speed of the bora are common.

Although the bora can be expected locally in the Aegean Sea whenever a cold anticyclone is present over either the Balkans or the Black Sea, the most extensive occurrences are associated with specific large-scale weather patterns over Europe and the eastern Atlantic Ocean. These synoptic patterns are discussed in detail in Para 2.3.

Weather associated with the bora depends primarily on the depth of the northerly or northeasterly flow. When the flow is shallow, 5,000 ft or less low clouds and rain with low visibilities are common; this is also the case when a depression is located just to the south. If the bora is accompanied by deep northerly or northeasterly flow, the skies are generally clear.

2.3 COLD OUTBREAKS OVER THE AEGEAN SEA

2.3.1 Introduction

Gale force northerly winds associated with cold outbreaks during the period September through May can create major operational problems in the Crete-Aegean Sea Area, during May, September and October, these cold outbreaks are often classified as etesians. A summary of a recently published study* of these cold outbreaks is given in Paras. 2.3.2 through 2.3.4.

2.3.2 Definition of an Intense Cold Outbreak

The criteria to verify the occurrence of a cold outbreak over the Aegean Sea are the following:

(1) The maximum temperature at Alexandronpolis for the first day of the cold surge, D day, is at least 5°C colder than on the previous day, D day minus 1.

(2) The maximum temperature at Alexandronpolis for the second day of the cold surge, D day plus 1, must be as cold as or colder than on D day.

(3) The maximum temperature for at least two of three stations -- Alexandronpolis, Lemnos, Skyros -- must be at least 5°C colder than normal for D day plus 1.

---

*Metaxas, D. A., 1978: Strong cold outbreaks in the east Mediterranean. A synoptic study. Rivista di Meteorologia Aeronautics, Vol. XXXVIII, No. 2, p. 95-105.

The data period for the Metaxas study was 1950-72. The mean monthly number of cases that met the three criteria during this period were:

J	F	M	A	M	J	J	A	S	O	N	D
0.7	0.5	0.4	0.3	0.04	0.1	0.1	0.04	0.4	0.4	0.5	0.7

The maximum frequency of cold outbreaks was found in December and January, and the minimum was found during the late spring and summer months of May through August.

2.3.3 Synoptic Conditions by Season

Surface and 500 mb synoptic conditions related to cold outbreaks were examined by season in the Metaxas study, with summer omitted due to scarcity of cases. Data from January, April and October were used to represent the other three seasons, winter, spring and autumn, respectively. Results of studies of composite charts for the three months (seasons) for D day-2 to D day+1 are given below.

January. During winter the main features at 500 mb found on D day-2 (Figure VI-3a) are a strong ridge in the eastern Atlantic along 5°-10°W and a strong trough over eastern Europe along 30°E. Also on this day a strong surface anticyclone is centered over Scotland and a rather weak low is located near Southern Italy (Figure VI-3b).

During the following three days, D day-1 through D day+1 (Figures VI-4 through VI-6), the 500 mb ridge moves slowly eastward to about 5°E-0°W and the accompanying 500 mb trough deepens southward over the Black Sea and Turkey. The strong anticyclone at the surface -- the most significant feature associated with the winter cold outbreak -- moves southeastward rapidly on D day-1, but moves more slowly on the following two days. This anticyclone is found over the Balkans by D day+1. The surface low over the central Mediterranean moves eastward over the Middle East by D day+1, but remains weak.

April. During spring on D day-2 (Figure VI-7a) a rather weak 500 mb ridge is found over the extreme eastern North Atlantic at about 10°-15°W, and a trough to the east extends from the Baltic Sea southwestward to Tunisia. This trough appears to be most intense over the Mediterranean. At the surface on D day-2 (Figure VI-7b), a significant low is located over Greece and a relatively weak ridge extends from Portugal northeastward into north central Europe.

The important changes at 500 mb during the next three days (D day-1 through D day+1; Figures VI-8 through VI-10) appear to be the eastward movement of the ridge to about 10°-15°E and the deepening and eastward movement of the southern part of the trough to about 25°E over the Mediterranean by D day+1. At the surface the well-developed low continues eastward to eastern Turkey while the high appears to strengthen only slowly as it extends eastward to the Balkans by D day+1.

October. During autumn the significant features on D day-2 at 500 mb (Figure VI-11a) are a rather strong trough about 10°-15°E over northern Europe and a somewhat weaker ridge at about 15°W south of Iceland. There appear to be no significant features at the surface on this day (Figure VI-11b).

Important changes are observed during the next three days (D day-1 through D day+1; Figures VI-12 through VI-14). At 500 mb, the trough/ridge system moves southeastward so that by D day+1 the trough is over the Aegean Sea (about 25°E) and the ridge is in the vicinity of the Alps (about 10°E). At the surface, anticyclogenesis takes place over the North Sea on D day-1 and intensifies as it moves southeastward to the Balkans two days later. A weak surface low also appears on D day-1 over Greece and the Aegean Sea, but it disappears by D day.

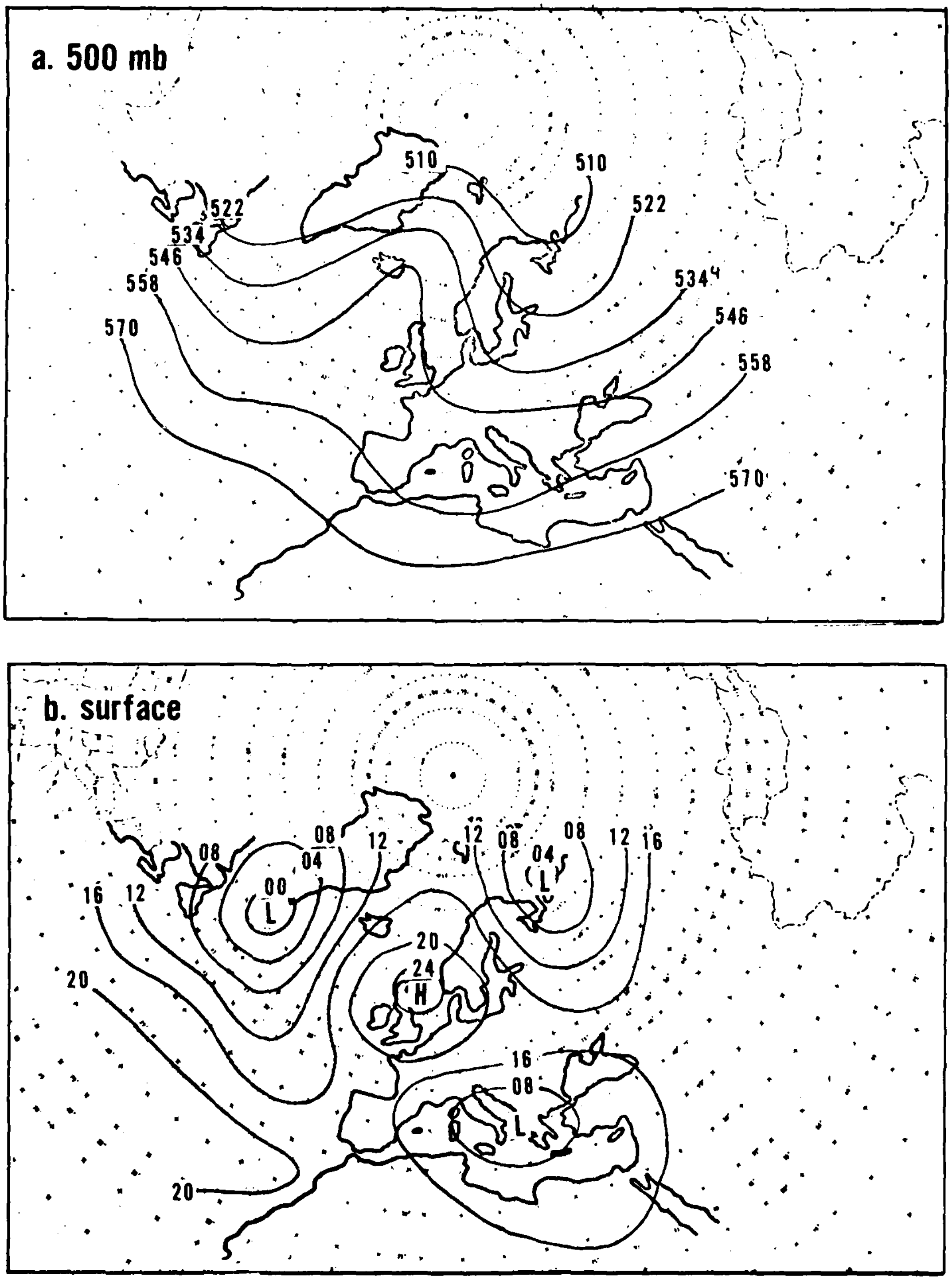


Figure VI-3. Synoptic conditions associated with a cold outbreak over the Aegean Sea. January, two days before the start (D day-2).

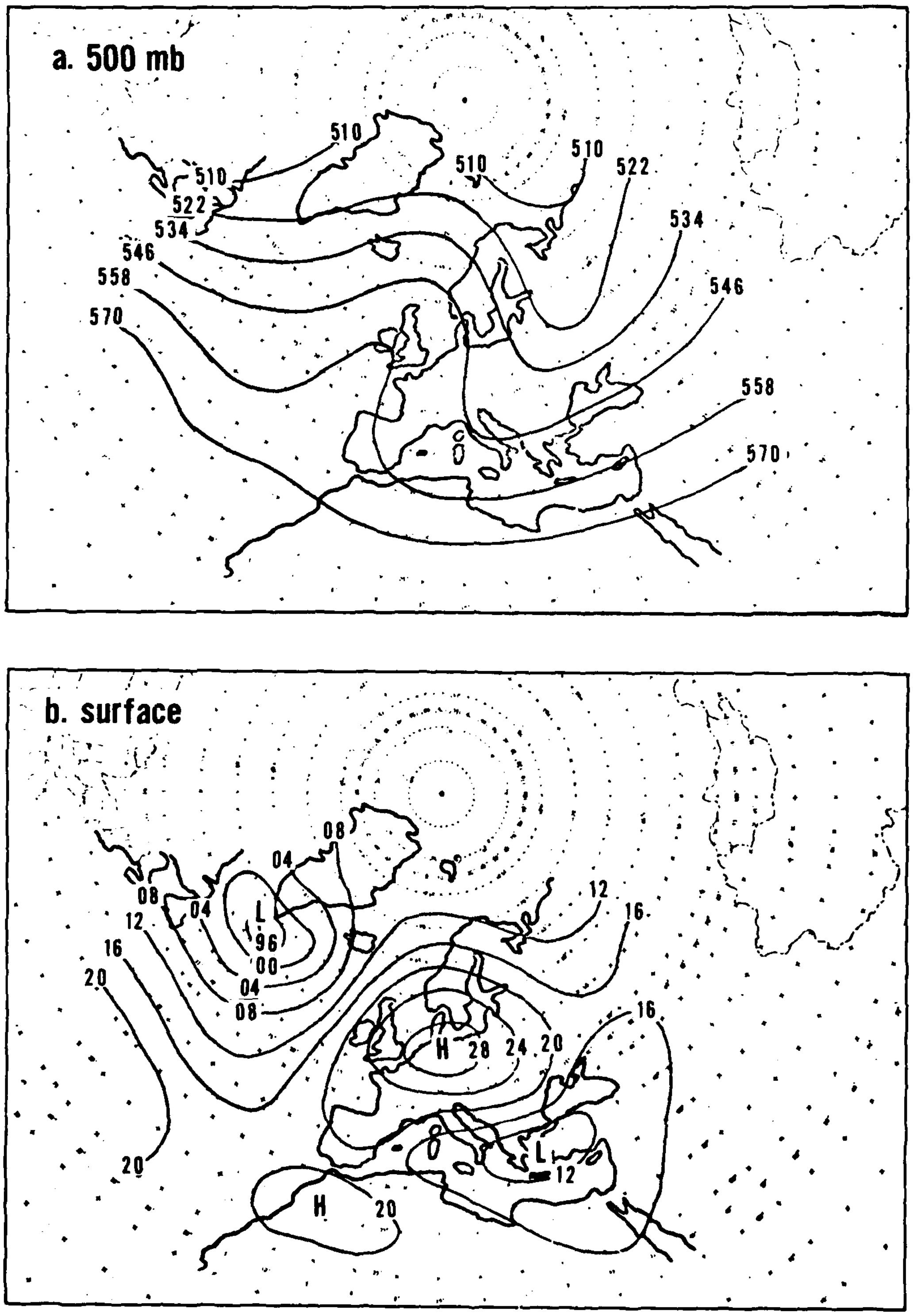


Figure VI-4. Synoptic conditions associated with a cold outbreak over the Aegean Sea. January, one day before the start (D day-1).

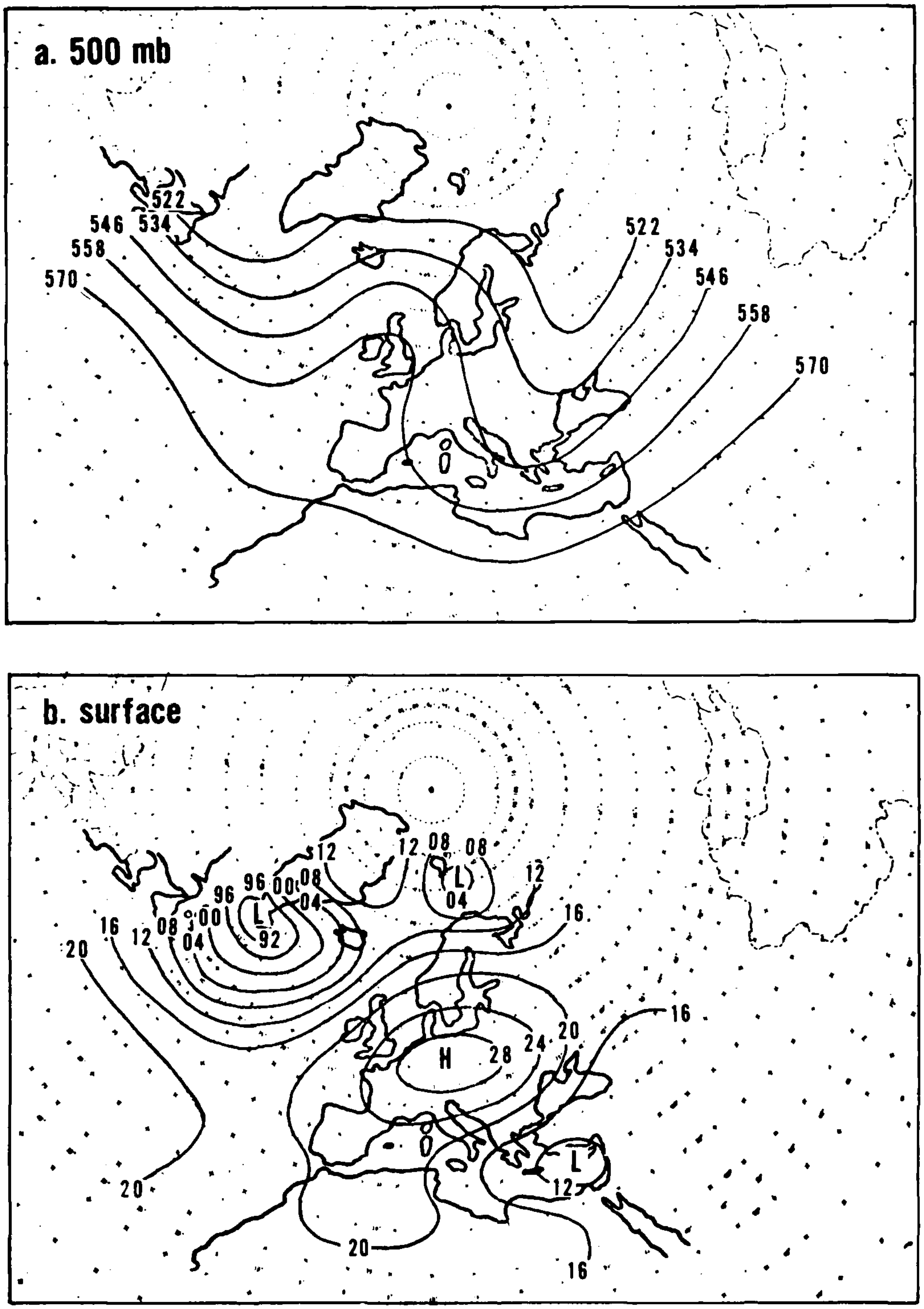


Figure VI-5. Synoptic conditions associated with a cold outbreak over the Aegean Sea. January, at the start (D day).

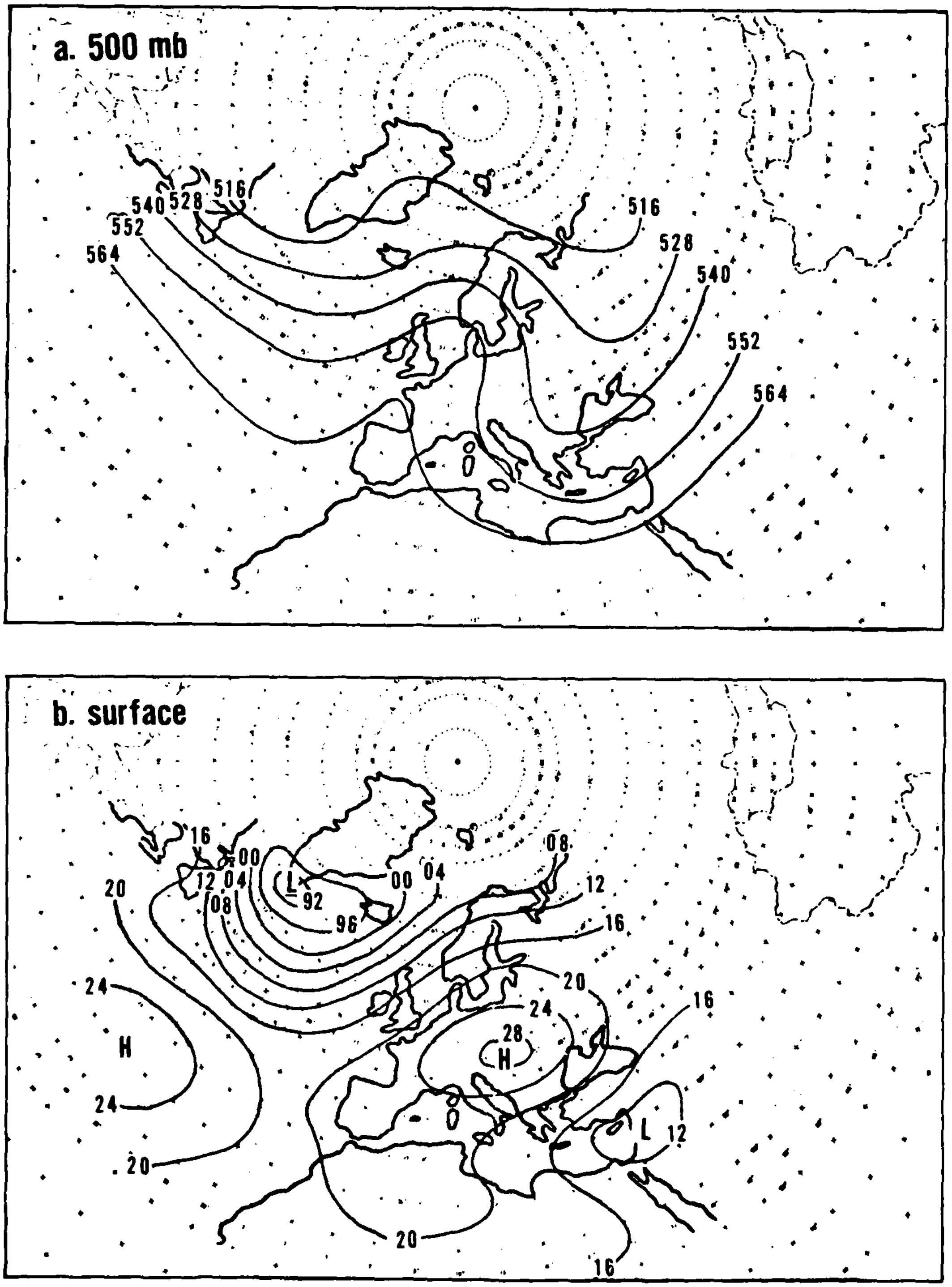
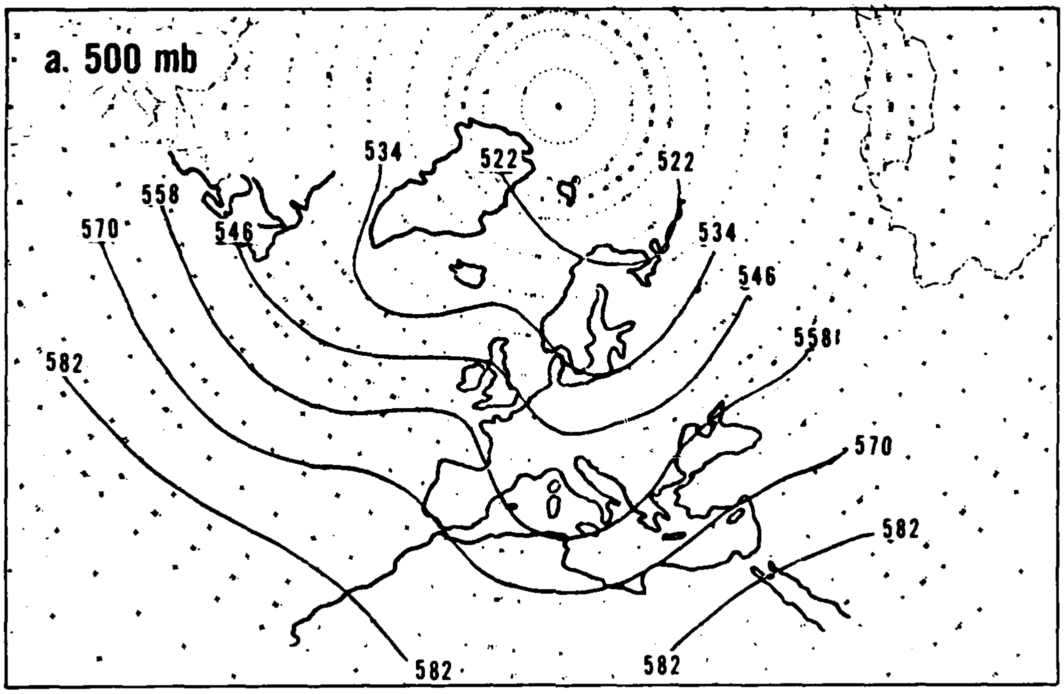


Figure VI-6. Synoptic conditions associated with a cold outbreak over the Aegean Sea. January, one day after the start (D day+1).



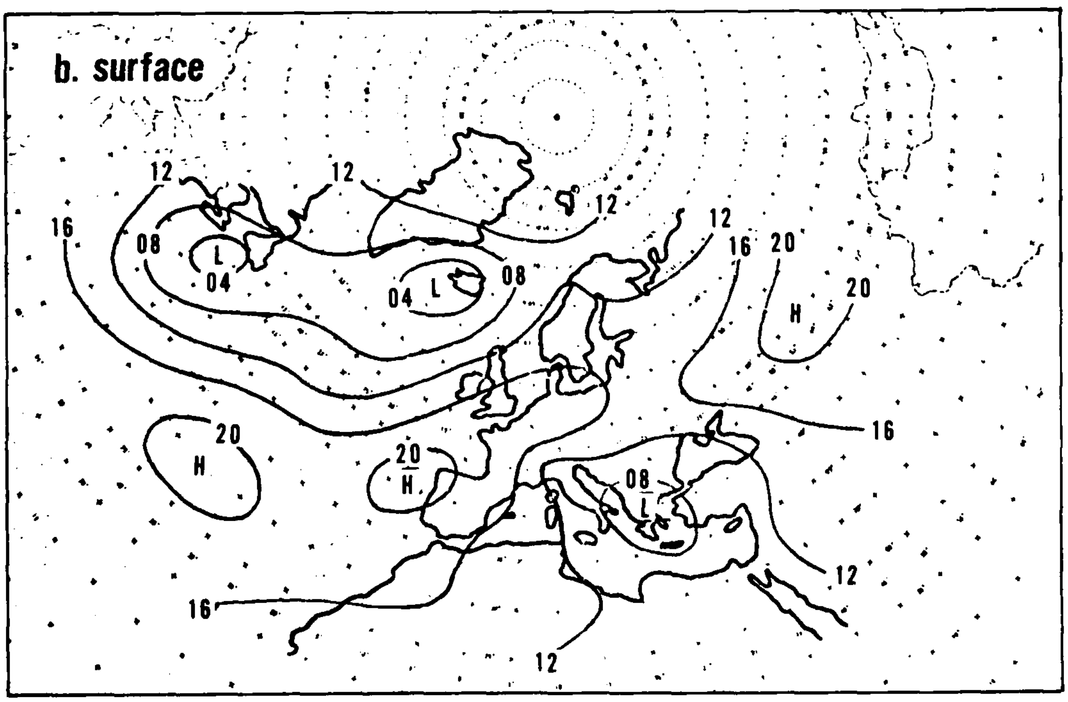


Figure VI-7. Synoptic conditions associated with a cold outbreak over the Aegean Sea. April, two days before the start (D day-2).

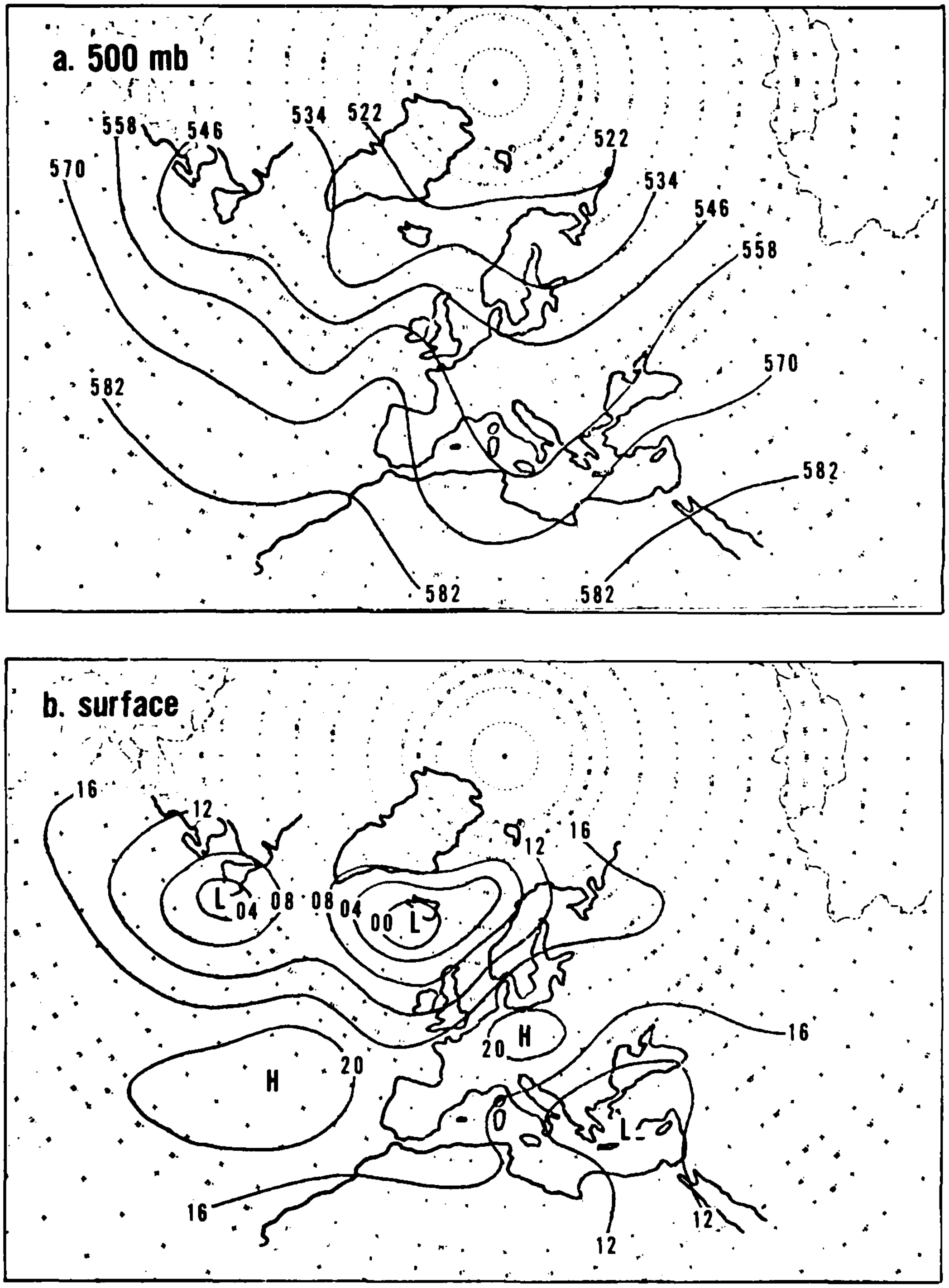
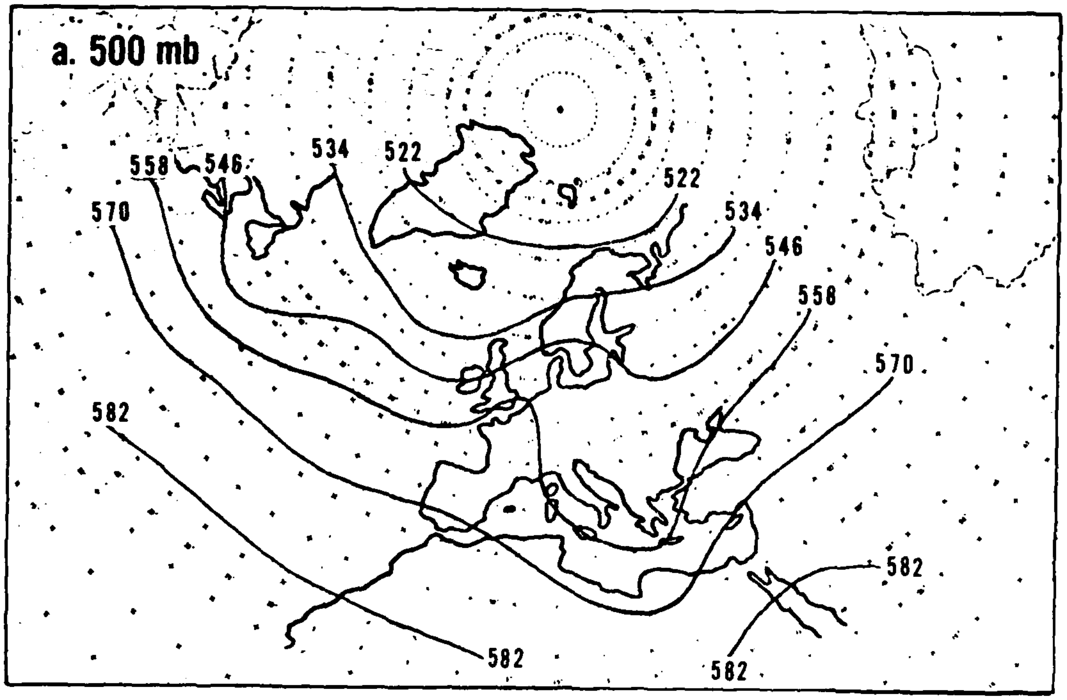


Figure VI-8. Synoptic conditions associated with a cold outbreak over the Aegean Sea. April, one day before the start (D day-1).



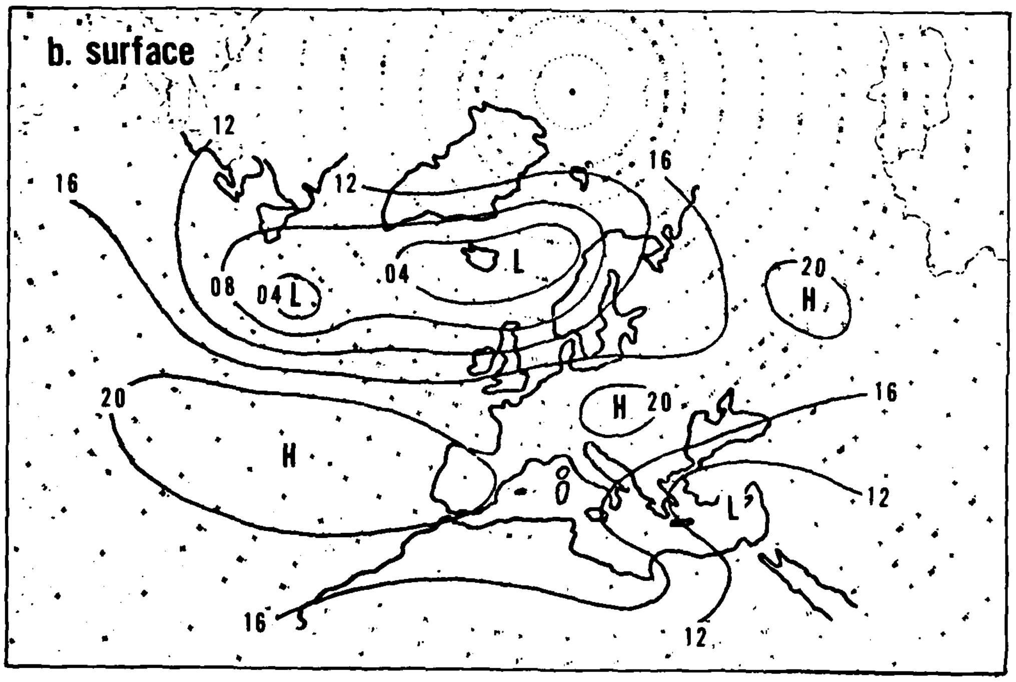


Figure VI-9. Synoptic conditions associated with a cold outbreak over the Aegean Sea. April, at the start (D day).

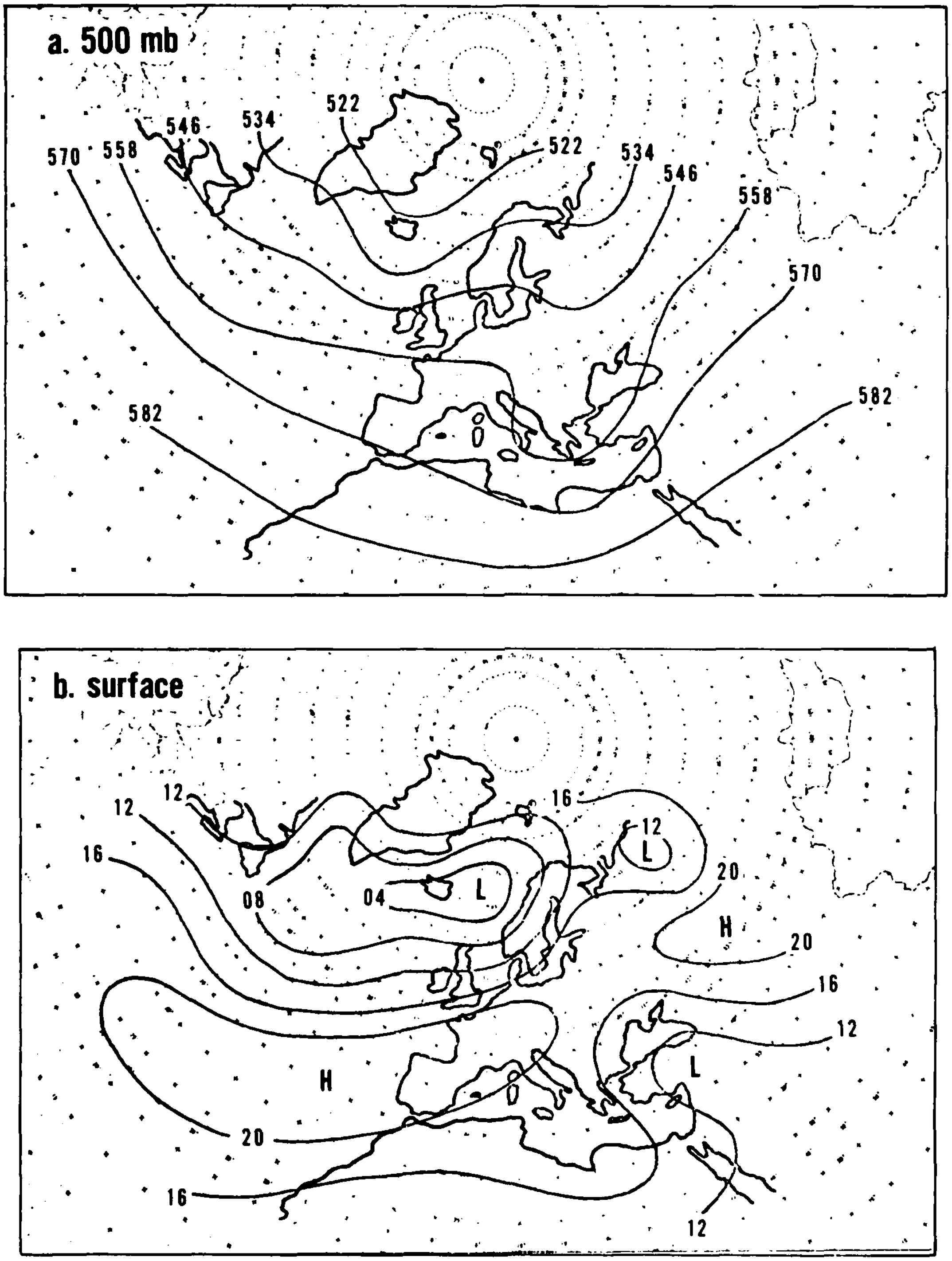


Figure VI-10. Synoptic conditions associated with a cold outbreak over the Aegean Sea. April, one day after the start (D day+1).

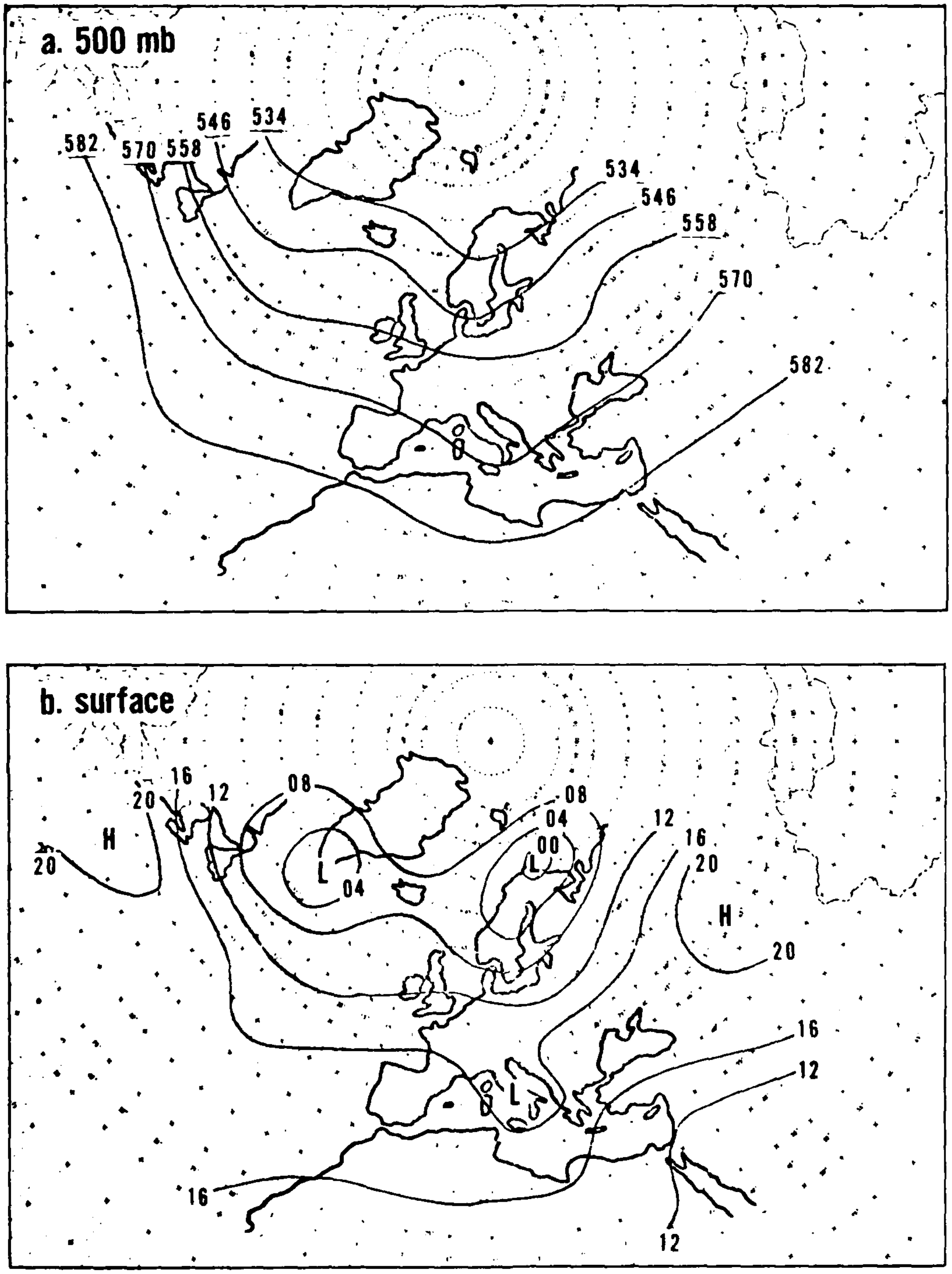


Figure VI-11. Synoptic conditions associated with a cold outbreak over the Aegean Sea. October, two days before the start (D day-2).

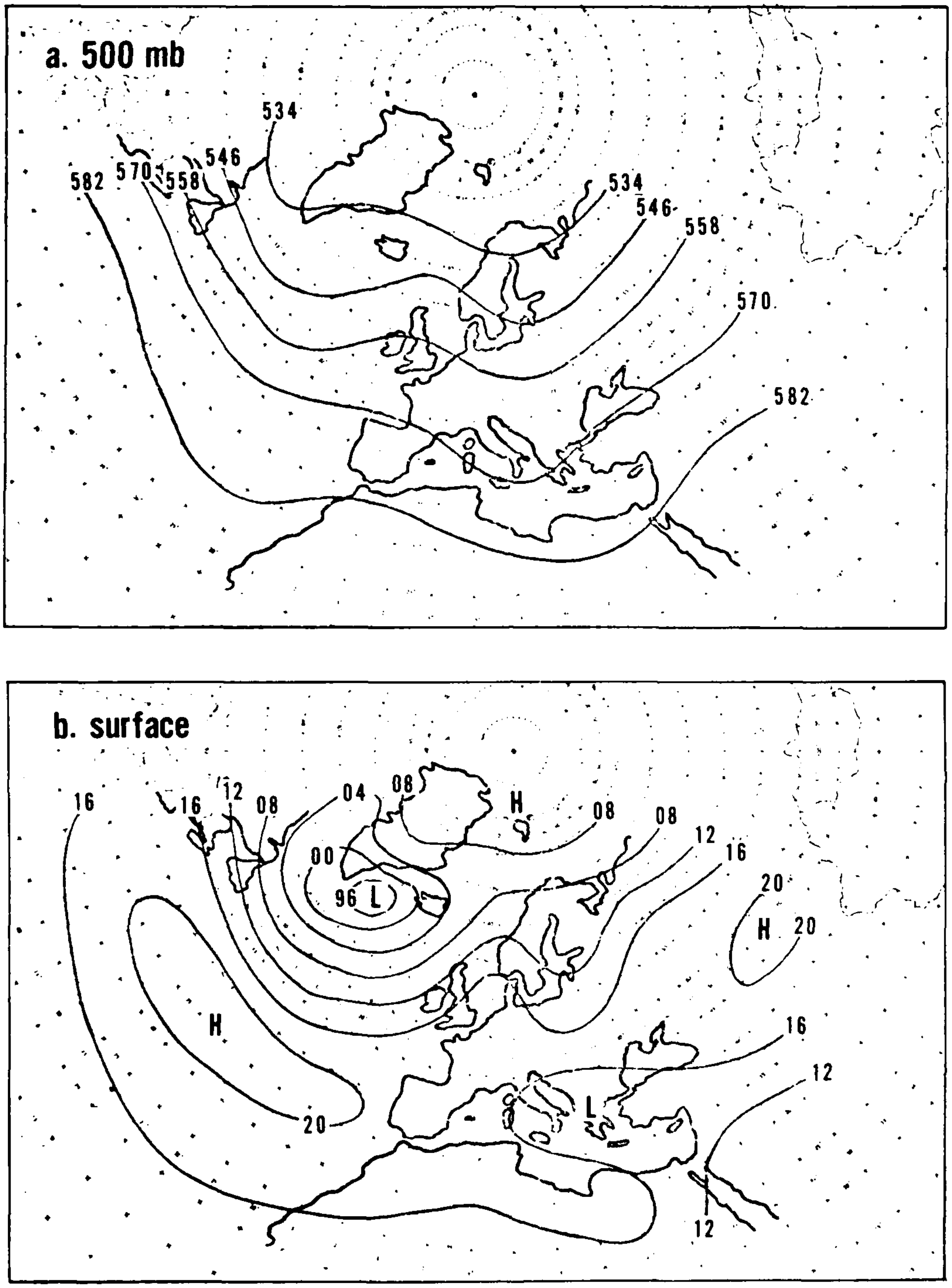


Figure VI-12. Synoptic conditions associated with a cold outbreak over the Aegean Sea. October, one day before the start (D day-1).

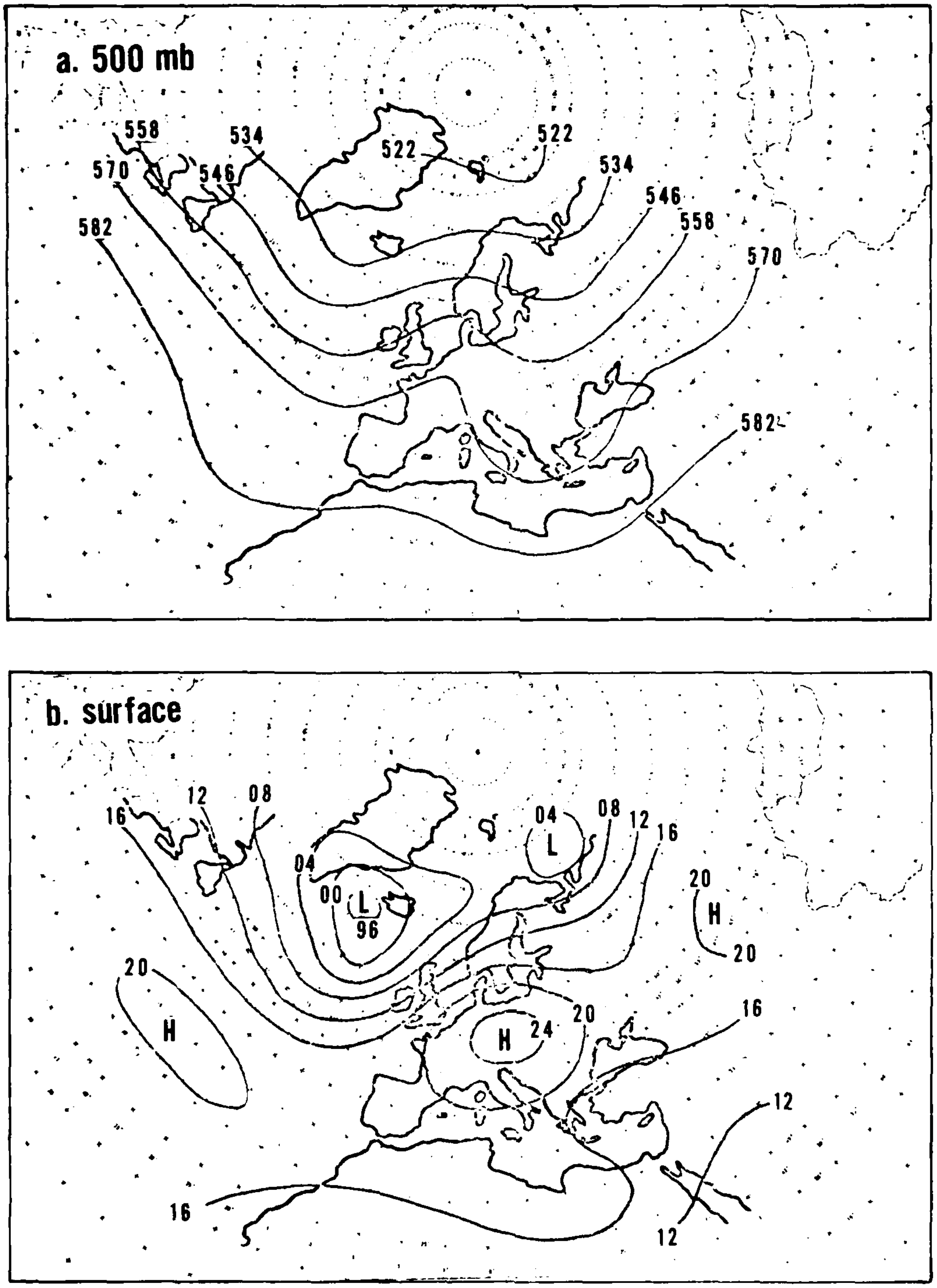


Figure VI-13. Synoptic conditions associated with a cold outbreak over the Aegean Sea. October, at the start (D day).

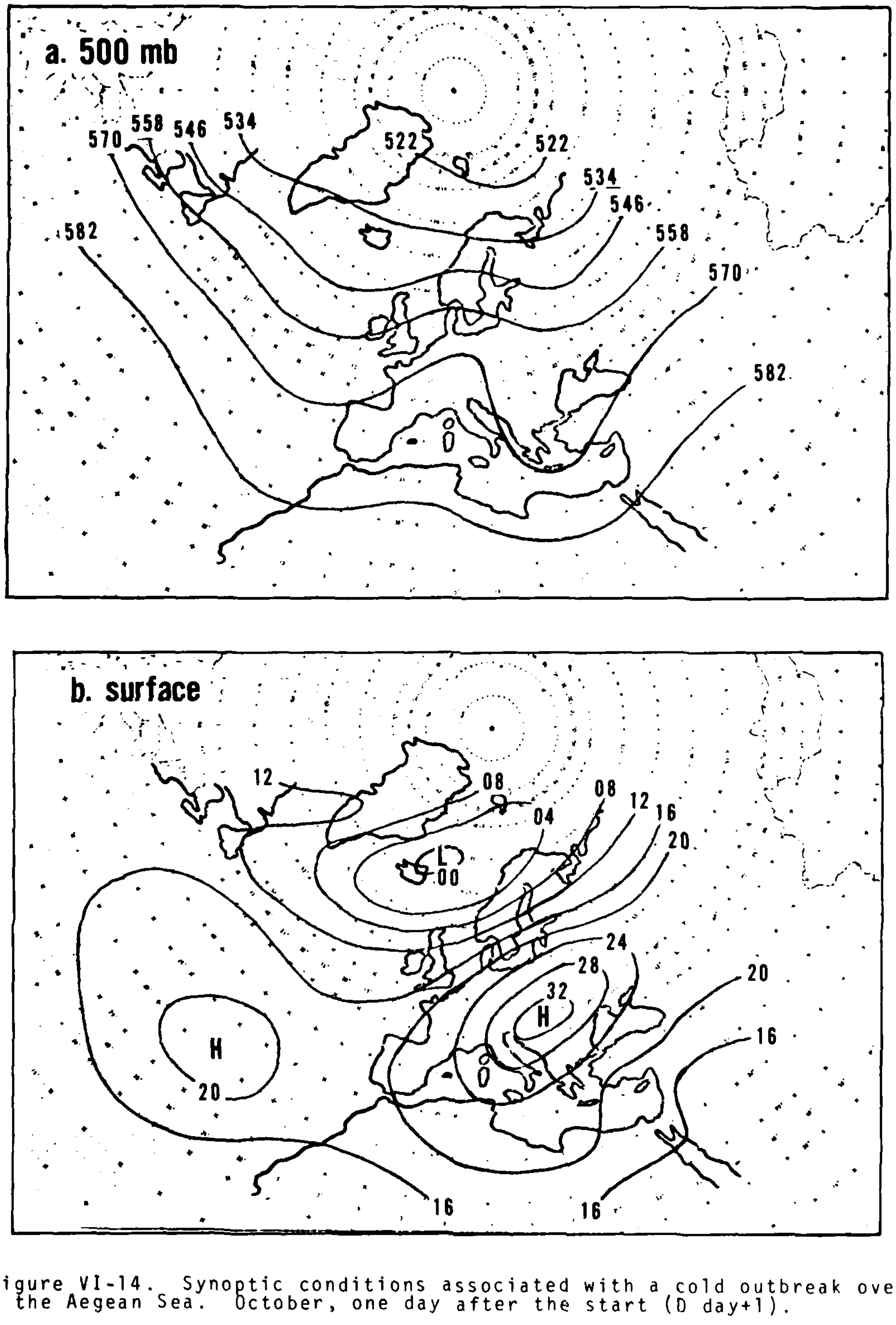


Figure VI-14. Synoptic conditions associated with a cold outbreak over the Aegean Sea. October, one day after the start (D day+1).

2.3.4 Summary

The following comparisons can be made to summarize the synoptic conditions associated with cold outbreaks over the Aegean Sea for the various seasons:

(1) At 500 mb, a ridge over the eastern North Atlantic and trough over central Europe on D day-2 seem to be necessary precursors to a cold outbreak. These features move eastward or southeastward throughout the period, so that by D day+1 the ridge has moved into western Europe and the trough has moved over eastern Europe.

(2) At the surface, the development and/or movement of a high cell into the region of the Balkans by D-day is evident. This high is strongest during winter, moving southeastward from Scotland on D day-2. During autumn the high appears to develop rapidly on D day-1. During spring, however, the much weaker high appears to be only a northeastward extension of the Azores anticyclone.

(3) Also at the surface, there usually is a low pressure system which, on moving eastward across the Aegean Sea during D-day, initiates the cold outbreak. This low appears to be of primary importance during the spring, of secondary importance during the winter, and of little importance during the autumn.

2.4 SIROCCO

The sirocco is a southeasterly to southwesterly wind over the Mediterranean that originates over North Africa. The source region is over deserts and thus the sirocco is extremely dry; it is warm in winter and hot in both spring and summer. Its influence occasionally extends over the entire Mediterranean Basin, but it is most pronounced in the Gulf of Gabes east of the Atlas Mountains (see Section V, Para. 2.1).

In the Crete-Aegean Sea Area, the sirocco is found east of cyclones moving eastward or northeastward toward Turkey or the Black Sea. It occurs most frequently during the cool season, November through April, and is most common in the southern and western Aegean Sea, the Cretan Sea and the Mirtoan Sea.

Wind speeds associated with the sirocco in this region are generally less than gale force. In the channels between the Dodecanese Islands and the Turkish mainland, however, gale force winds can be experienced.

Because of the sirocco's long overwater trajectory, its air is always moist in the lower layers. Low stratus, fog and drizzle with associated low visibilities are common. Heavy rain is also likely near frontal boundaries and along topographical barriers.

2.5 CYCLONE OCCURRENCES

Cyclonic activity within the Crete-Aegean Sea Area usually originates in one of three locations: the Southern Aegean Sea/Cretan Sea, the Ionian Sea, or North Africa (North African cyclones).

2.5.1 Southern Aegean Sea/Cretan Sea Cyclone

Cyclogenesis over the Aegean Sea/Cretan Sea is most likely to occur during the autumn and winter. A vigorous invasion of cold air (see Para. 2.3) is an essential requirement for rapid development of these depressions. Depressions forming along the leading edge of the cold surge may move southward or even southwestward at first, but later they tend to move eastward to the Cyprus area (see Figure VI-15).

Heavy rain with poor visibilities can be expected in association with these cyclones. Gale force winds are also likely near and to the north of these depressions.

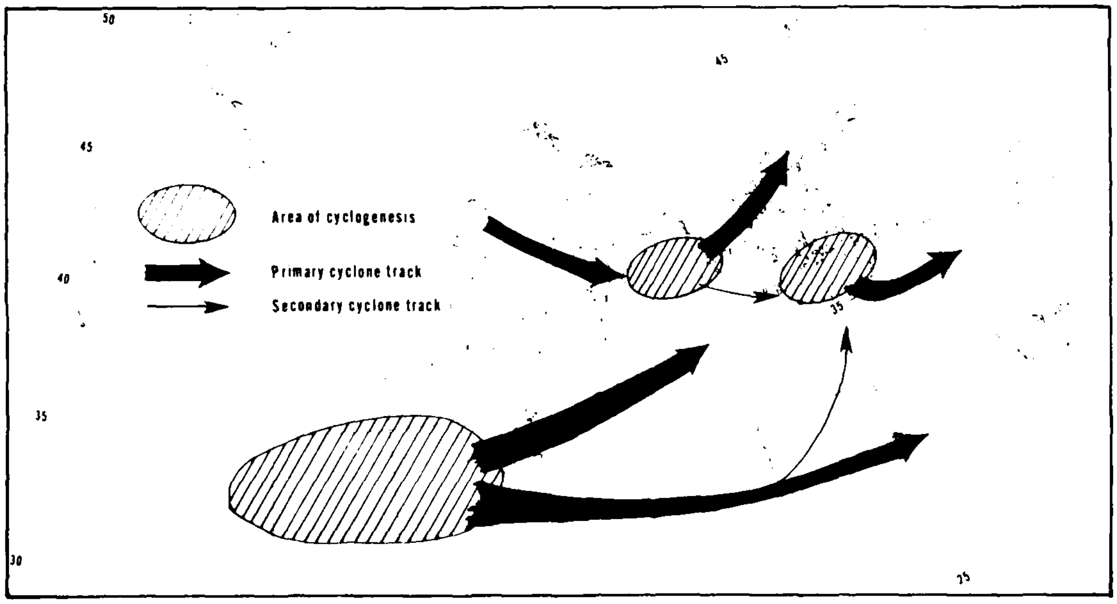


Figure VI-15. Areas of cyclogenesis and tracks of cyclones which affect the Crete-Aegean Sea Area.

2.5.2 Ionian Sea Cyclone

Cyclones approaching the Crete-Aegean Sea Area from the Ionian Sea usually originate over the Gulf of Genoa, moving southeastward along the west coast of Italy before either moving directly into the Ionian Sea or, as is often the case, becoming stationary near southern Italy. If the latter occurs, a new center will develop to the east over the Ionian Sea. If they are associated with a strong bora over the Adriatic Sea, these systems over the Ionian Sea become quite intense.

If a cold surge is present to the north, the direction of movement of the Ionian Sea cyclone will be eastward across the southern Aegean Sea or Cretan Sea. If cold air is not present over the Aegean Sea, the Ionian Sea cyclone will most likely move northeastward across Greece toward the Black Sea. As in the case of cyclones crossing southern Italy, a new center is likely to form over the western Aegean Sea if the primary system becomes stationary off the west coast of Greece.

2.5.3 North African Cyclone

North African cyclones (see Section V, Para. 2.5.1) develop over desert region south of the Atlas Mountains. These systems generally move northeastward upon reaching the Tunisia/Gulf of Gabes region, but may continue moving eastward south of the North African coast. The possibility of different tracks (see Figure VI-15) makes it very difficult to forecast when and if North African cyclones will affect the Crete-Aegean Sea Area.

When such cyclones are present, gale force winds are very common. Sirocco winds will occur ahead of the depression. Even stronger winds are likely to the west of a low tracking northeastward, particularly with the arrival of cold air aloft (seen at 500 mb).

3. FORECASTING RULES

Tables VI-1 through VI-5 provide quick reference to the 48 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location within the area of interest. Observing stations locations are shown in Figure VI-16 and listed in Table VI-6.

Table VI-1. Forecasting rules for the etesian.

Onset		Rules 1-3
Cessation		Rules 4, 5
Duration		Rules 6-8
Intensity	General	Rules 9, 10
	Local Variations	Rules 11-15
Weather		Rules 16, 17

Table VI-2. Forecasting rules for cold surges and associated bora type winds.

Onset		Rules 18-20
Intensity	General	Rule 9
	Local Variations	Rules 21-24
Extent and Duration		Rules 25, 26
Miscellaneous		Rule 27

Table VI-3. Forecasting rules for cyclonic activity.

Direction of Movement	Rules 28-32
Cyclogenesis	Rules 33, 34

Table VI-4. Miscellaneous rules.

Wind Speed		Rule 9
Frontal Movement		Rule 35
Station Reports	SFC Wind	Rule 36
	Sea-Level Pressure	Rules 37, 38
Haze		Rules 39-41

Table VI-5. Forecasting rules for ports and anchorages.

Souda Bay	Rules 26, 42-45
Thessaloniki	Rule 46
Athens	Rules 47, 48

Table VI-6. List of observing stations.

Name of Station	Block No.	Index No.
Alexandronpolis	16	627
Athens/Hellenikon	16	716
Estanbul/Yesilkoy	17	060
Kythira	16	743
Lemnos	16	651
Naxos	16	732
Piraeus	16	717
Rodos/Maritsai	16	749
Sitia	16	757
Skyros	16	684
Souda Bay	16	746
Thessaloniki	16	622
Tybakion	16	759
Tripolis	16	710

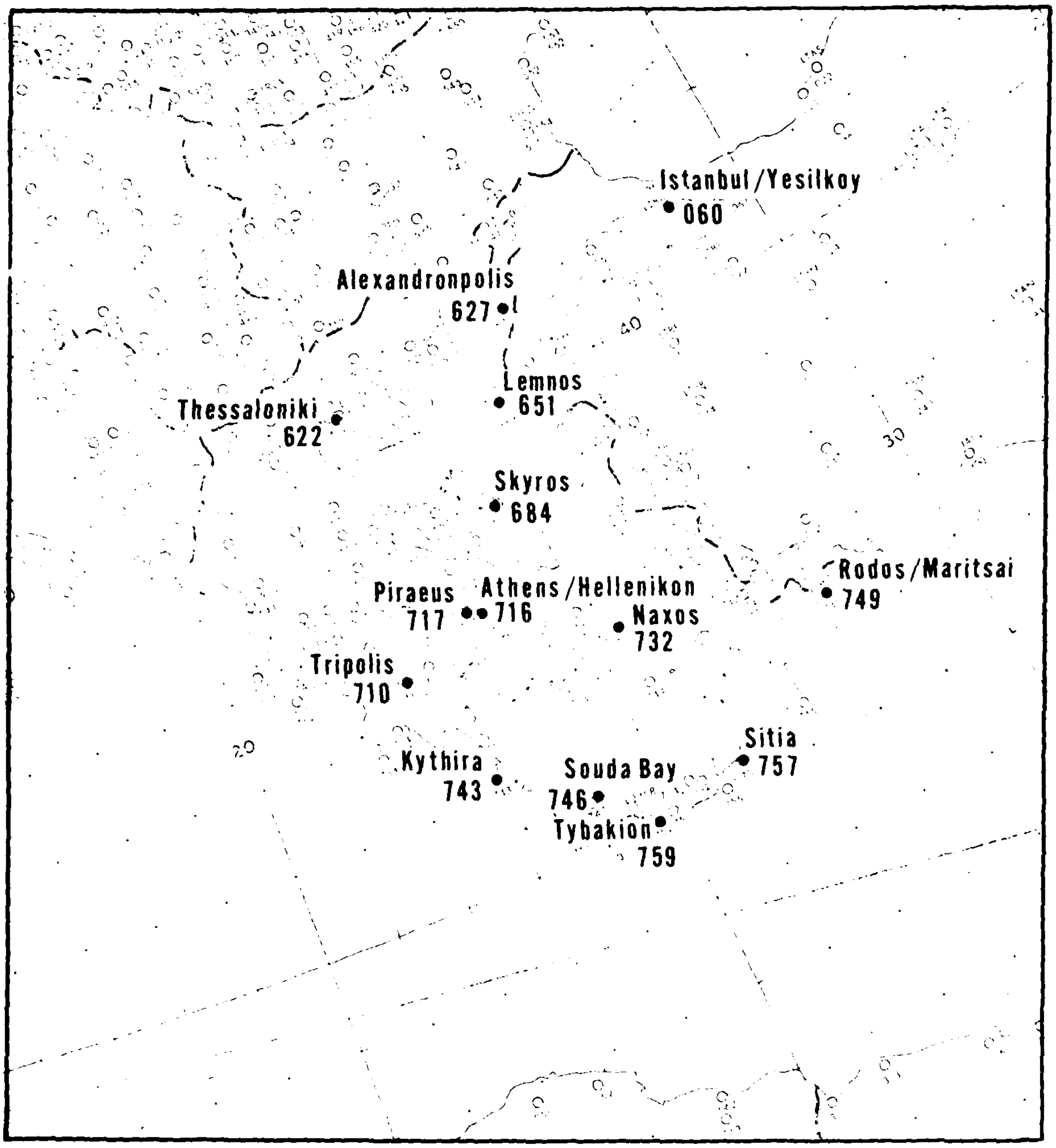


Figure VI-16. Station locator map for the Crete-Aegean Sea Area.

ETESIAN, ONSET, RULES 1-3

1. Forecast a gale force etesian to occur when a strong ridge (SD maximum) is predicted over France and a strong trough (SD minimum) is predicted over the Ionian Sea, northern Greece and the eastern Balkans, both at 500 mb (see Figure VI-17).

2. Forecast a gale force etesian to occur when cyclogenesis over Asia Minor and anticyclogenesis over the Balkans are predicted.

3. The movement southward or southeastward of a cold front is necessary for the establishment of a gale force etesian.

ETESIAN, CESSATION RULES 4, 5

4. Forecast the cessation of gale force etesian winds when a ridge (SD maximum(is expected to move over the southern Ionian Sea at 500 mb (see Figure VI-18).

5. The mistral and the etesian occur out of phase: if one prevails, the other is suppressed. Therefore, if the onset of mistral conditions is predicted, the gale force etesian should end.

ETESIAN, DURATION RULES 6-8

6. With fast-moving systems the subsequent etesian period is short, less than five days. The passing trough-ridge pattern is shallow, with westerlies prevailing aloft. Another etesian period frequently follows within a short time.

7. An extended etesian period is likely if there is a deep surface depression in the Black Sea region, associated with a cut-off low at 500 mb. Strong northerly winds prevail at upper levels over the Aegean Sea.

8. A blocking long-wave ridge over France and western Germany is associated with extended etesian periods of five days or more.

ETESIAN, INTENSITY RULES 9-15

9. The following pressure differences associated with northerly/southerly winds of 25-35 kt over the Aegean Sea are 7.5 mb between Rodos/Maritsai and Istanbul/Yesilkoy; and 6.0 mb between Rodos/Maritsai and Athens/Hellenikon.

10. Maximum winds during an etesian occurrence should be predicted along a line running from slightly east of Lemnos and Skyros, through the Cyclades and then through the opening between Rhodes and Crete (see Figure VI-19).

11. The strength of the etesian is greatly increased by channeling. This channeling is most evident in the Doro Channel between the islands of Euboea and Andros, in the channel between the mainland of Turkey and the Dodecanese Islands, and in the area between Paros and Naxos as far south as Thira (see Figure VI-19).

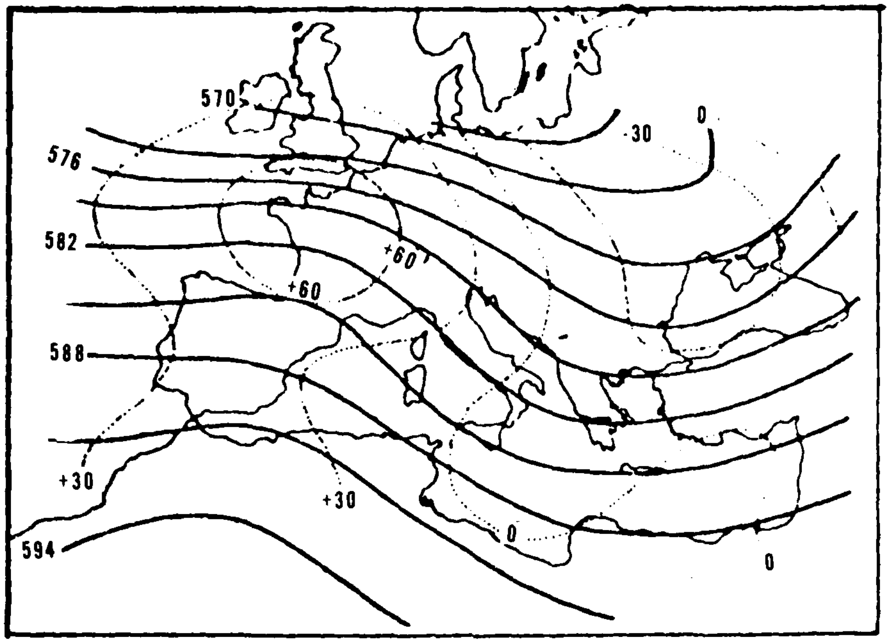


Figure VI-17. Mean 500-mb chart during the first day of an etesian. Dash lines are anomalies from the climatological mean.

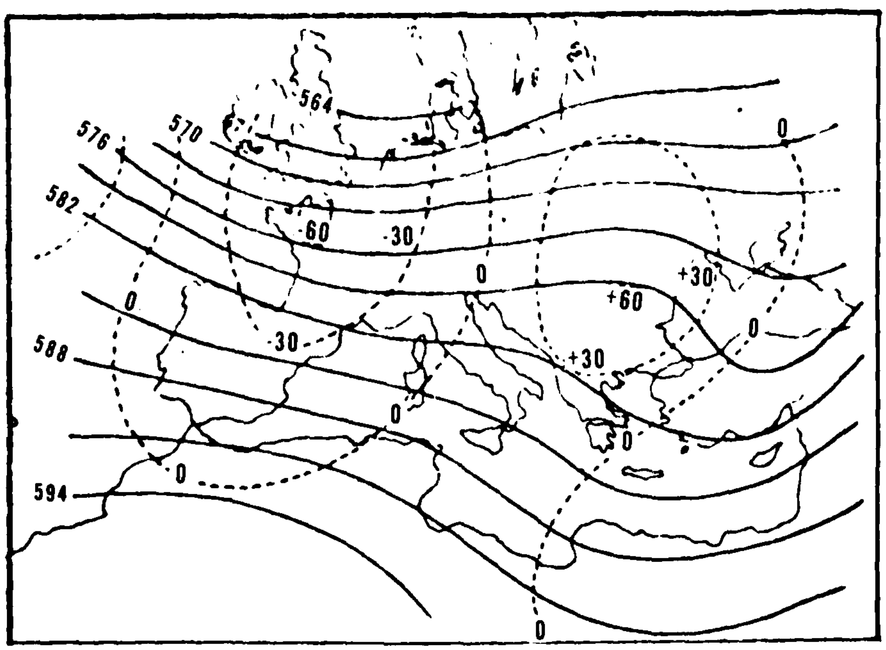


Figure VI-18. Mean 500-mb chart at the cessation of an etesian. Dash lines are anomalies from the climatological mean.

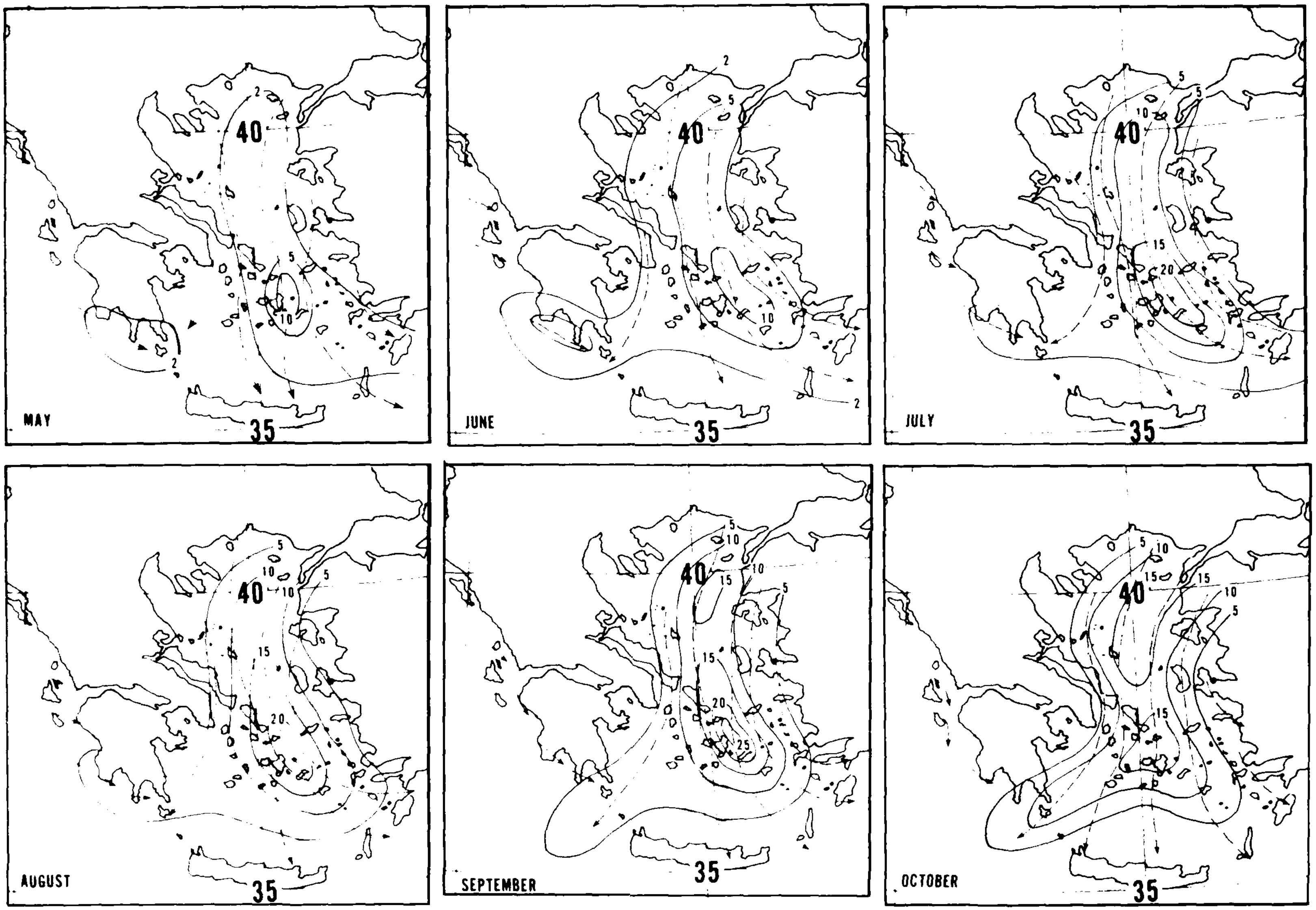


Figure VI-19. Wind patterns during etesians. Dash lines are streamlines and solid lines are percent frequency of winds greater than 22 kt.

12. In well-formed etesian situations, winds in excess of 27 kt are frequent along the south coast of Crete at valley exits.

13. During an etesian, gale force winds extend into the area just east of Crete and south of Rhodes. Northerly winds 20-25 kt in the Aegean Sea increase to 25-32 kt with higher gusts off the coast of eastern Crete.

14. Observations of the etesian in the sea area east of Crete (40 n mi radius of 34.5°N, 27°E; shown in Figure VI-20) indicate that winds in this area are 100% of the geostrophic speeds due to the channeling effect between Crete and the neighboring island of Karpathos. The direction of the flow is across the isobars of an angle of approximately 45° toward Asia Minor. The pressure gradient used to estimate wind speed is determined by using the pressure difference, Rodos minus Sitia.

15. During strong etesian conditions over the Aegean Sea, the wind at Rodos becomes almost calm. A surface low tends to form over Rhodes under these conditions.

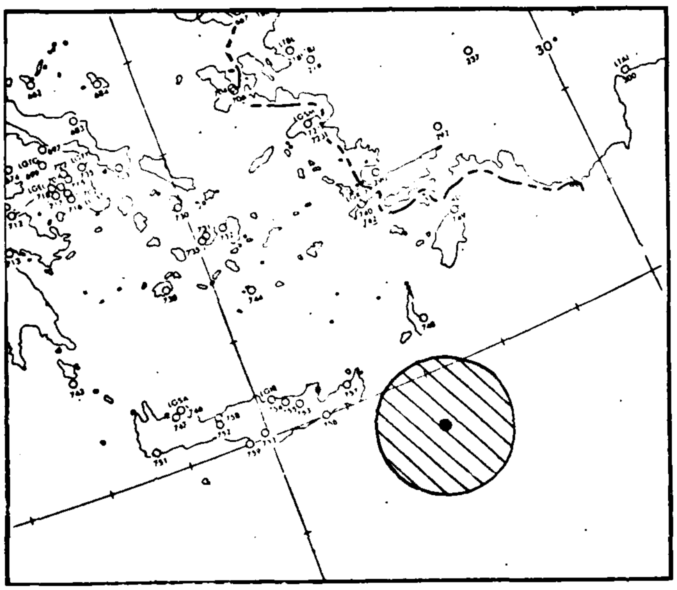


Figure VI-20. Area of maximum winds during an etesian (40 n mi radius centered at 34.5°N, 27°E).

ETESIAN, ASSOCIATED WEATHER RULES 16, 17

16. Thunderstorm activity is often present on the day preceding the establishment of the etesian during May-June and September-October. Although these thunderstorms have been known to spread as far south as Athens, they are usually found only over the northern Aegean Sea.

17. Dust and haze are often observed during gale force etesians.

COLD SURGES AND BORA TYPE WINDS, ONSET RULES 18-20

18. Necessary precursors for a cold outbreak to occur over the Aegean Sea within 48 hr are a ridge at 500 mb over the eastern North Atlantic and a trough at 500 mb over central Europe.

19. Forecast a cold outbreak to occur over the Aegean Sea with the arrival or development of a high cell over the Balkans. During the winter the high is likely to be located over Scotland 48 hr before the frontal passage (see Figure VI-3). During autumn the high appears to develop over the Balkans 24 hr before frontal passage (compare Figure VI-11 with VI-12).

20. The eastward movement of a surface cyclone across the Aegean Sea appears to initiate a cold outbreak. This low is of primary importance during the spring.

COLD SURGES AND BORA TYPE WIND, INTENSITY, RULES 21-24

21a. During cold outbreaks in the Aegean Sea, if the synoptic scale pressure gradient favors deep northeasterly airflow (greater than 5000 ft), forecast violent squalls off Cape Tainaron (Matapan). Squalls are also likely along the leeward slopes of the high ground in the Cyclades, Euboea, the Gulf of Thermaikos and Crete.

21b. During deep northerly airflow (greater than 5000 ft), forecast squalls on the leeside of high ground south of Mount Athos; on the Pelion Peninsula; on the east and south side of Euboea; on all the islands of the Cyclades that have high mountains, especially those north of Melos (Milos); in the Gulfs of Patrai and Corinth; and on the western half of the south coast of Crete.

22. During cold outbreaks in the Aegean Sea, there are wind increases caused by strong funneling of the air stream in both the Doro Channel between the islands of Euboea and Andros and the channel between Crete and the Peloponnesus.

23. During deep cold outbreaks in the Aegean Sea, a ravine-type wind occurs at Tybakion, Crete, which lies on the south side of the island at the foot of Mount Ida. Speeds of northerly winds at Tybakion may be double, or more, the speeds occurring on the north side of the island.

24. If relatively shallow (5000 ft or less) northeasterly winds are present during cold outbreaks in the Aegean Sea, the Gulf of Thermaikos, the western thoroughfare of Euboea, the greater part of the Gulf of Corinth, and the Gulf of Patrai will all experience weak winds even though strong northeasterly winds are blowing in the open sea.

COLD SURGES AND BORA TYPE WINDS, EXTENT AND DURATION RULES 25, 26

25. Besides the Gulf of Lion, which experiences the mistral, and the Alboran Channel, which experiences the levante, the only other large area of persistent gale force winds is the Aegean Sea. These extended periods of gales, lasting up to one week, occur in the wakes of cold fronts that move southward and stall in the area of Crete.

26. Cold fronts moving southward through the Aegean Sea frequently stall on reaching the latitudes of Crete. On the north side of the island, under this situation, winds are northerly and the weather is poor with low clouds and drizzle. On the south side of the island, however, southerly winds with clear skies and warm temperatures occur. The occurrence of the stationary front along the mountains of Crete can persist up to a week. Because of the strong winds at Souda Bay, ceilings and visibilities remain good.

COLD SURGES AND BORA TYPE WINDS, MISCELLANEOUS RULE 27

27. Northeasterly winds are funneled through the Dardannelles, which causes high seas over the Northern Aegean.

CYCLONIC ACTIVITY, MOVEMENT RULES 28-32

28. During the spring, a North African cyclone that has moved out over the Mediterranean will generally track toward the northeast if the heat trough over Turkey is deeper than 1000 mb. However, if a surface high or only a weak low is present over Turkey, expect the North African cyclone to become stationary over the Ionian Sea 75 of the time.

29. Increasing southeasterly winds at Souda Bay are an indication that a North African cyclone is moving toward Crete.

30. A cyclone that develops on the southern edge of a cold surge over the Aegean Sea may move southward or even southwestward at first, but normally it will move eastward to the Cyprus area later.

31. If a cold surge is occurring over the Aegean Sea, a low moving toward the region from the Ionian Sea should be forecast to move eastward across either the southern Aegean Sea or the Cretan Sea. If the cold surge is not present, forecast the approaching cyclone to move northeastward.

32. Surface lows moving across the Ionian Sea appear to fill when they reach Greece. When this occurs, a new center usually develops to the east over the Aegean Sea; thus the center of the low appears to jump across the land mass.

CYCLONIC ACTIVITY, CYCLOGENESIS RULES 33, 34

33. Remnants of old cold fronts should be followed closely. In several cases cyclogenesis has originated along one of these fronts, even after cloudiness associated with the fronts had disappeared. This phenomenon has occurred when an upper level shortwave trough (SD minimum) approached from the west.

34. A necessary (though not sufficient in itself) requirement for rapid cyclogenesis over the southern Aegean/Cretan Sea area is the southward movement of a cold outbreak across the Aegean Sea (see Table VI-2 for forecasting rules).

MISCELLANEOUS RULES, FRONTAL MOVEMENT, Rule 35

35. Shallow cold fronts approaching the Mediterranean Basin are greatly retarded by the mountain barriers. Deep cold fronts (those detectable at the 700 mb level) are not hindered by terrain features, and at times even undergo acceleration. The 400 mb level appears to be useful in forecasting this acceleration.

MISCELLANEOUS RULES STATION REPORTS, RULES 36-38

36. The surface wind report at Kythira is representative of the well-known funnel effect between mainland Greece and Crete, and is usually valid for a narrow belt of 5-10 n mi wide. This wind is valid for a somewhat more extensive region, however, if a well marked northeast gradient exists.

37. The sea level pressure at Rodos/Maritsai appears to be about 2 mb too low. However, this apparent discrepancy may be the result of the lee trough present at this station especially during the summer.

38. The sea level pressure reported at Tripolis appears to be about 2 mb too high.

MISCELLANEOUS RULES, HAZE RULES 39-41

39. Salt haze is a serious problem for flight operations over the Mediterranean. This haze has the following characteristics:

(1) It is most prevalent during the summer and early autumn.

(2) Its color is bluish white, as opposed to the brown of dust haz

(3) Salt haze scatters and reflects light rays much more than does dust haze.

(4) Salt haze sometimes extends to over 12,000 ft and has been reported up to 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi, the slant visibilities for a pilot making a landing approach may be near zero, especially if the approach is in the general direction of the sun.

(6) Salt haze is sometimes thicker aloft than at the surface.

(7) Salt haze is less of a problem after sunset since the poor visibility is caused partially by scattering and reflection.

40. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing. It is especially prevalent when there is a strong ridge present at the surface and aloft.

41. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. Visibilities will improve, however, if there is an increase in the wind speeds at the 850 and/or 700 mb levels.

PORTS AND ANCHORAGES, SOUDA BAY RULES 42-45

42. At Souda Bay, the local topography causes basic south to southwesterly flow at the gradient level to be verified as either southeasterly or west-northwesterly flow at station level.

43. Cold fronts approaching from the west at Souda Bay do not cause a significant wind change following their passage. Because of the local topography, winds are 270°-290° before and after frontal passages.

44. Several local wind variations have been observed at the meteorological site at Souda Bay:

(1) If the expected wind direction is from 270°-010°, the observed direction at the site will be westerly.

(2) If the expected wind direction is from 020°-090°, the observed direction at the site will be easterly.

(3) Observed wind directions along the runway frequently are 180° different from one end to the other.

45. The outer harbor at Souda Bay, Crete, is affected by strong northerly to northeasterly winds. During strong etesian situations in the summer and cold surges in the winter, ships are often required to move farther into the harbor.

PORTS AND ANCHORAGES, THESSALONIKI; ATHENS RULES 46-48

46. The carrier anchorage at Thessaloniki is quite exposed to gale force winds from the north out of the Vardar Valley.

47. The following are boating conditions for the harbor of Athens (Piraeus) as a function of wind direction:

(1) Southeasterly to southerly winds, 120° to 200°. The most hazardous wind direction. Harbor is exposed to both wind and sea from this direction Wave height is comparable with that of a fully developed sea. Wave action at boat landings can make it impossible to embark or debark. Highest winds and most severe conditions result from a depression passing to the south of Athens but north of Crete.

(2) Southwesterly to northerly winds, 200° to 360°. Takes much higher winds to build significant waves. Westerly winds in excess of 24 kt can cause boating problems in the eastern part of the harbor. Westerly winds occur with depressions tracking over and to north of Athens.

(3) Northerly to southeasterly winds, 360° to 120°. Ideal direction is from the north-northeast and in association with cold surges during the winter and etesians during the summer. During these situations, seas build to seaward. If wind speed is 15-25 kt or less, forecast winds to shift to southerly in the afternoon (for sea breeze effect, see Rule 48). If north-northeasterly winds are greater than 25 kt, there will be no afternoon sea breeze.

48. The summer wind pattern at the harbor of Athens (Piraeus) is as follows: during the morning the wind picks up 8-15 kt from the northeast; by early afternoon the sea breeze takes over, causing the wind to shift around to the south to southwest with speeds 10-15 kt; after sunset the normal etesian wind regime re-establishes with northeasterlies 5-10 kt.

VII. EASTERN MEDITERRANEAN AREA

1. OVERVIEW

1.1 REGIONAL GEOGRAPHY

The Eastern Mediterranean Area* shown in Figure VII-1 encompasses the Mediterranean Sea eastward from the Peloponnesus, excluding the Sea of Crete. The Black Sea is mentioned only briefly since few forecasting rules are available for that sea area.

Major topographical features (Figure VII-1) are found along both the northern and eastern edges of the eastern Mediterranean. To the north, the mountainous island of Crete separates the eastern Mediterranean from the Sea of Crete and Aegean Sea. To the northeast, the Bey Daglari and Taurus Mountains of southern Turkey act as major barriers to airflow. There are major gaps in these mountain chains of southern Turkey, however, the Gulf of Antalya between the Bey Daglari and Taurus Mountains; and the Goksu Valley located within the Taurus Mountains.

To the east of the eastern Mediterranean, mountains extend from the Sinai Peninsula to the Gulf of Iskendrun at elevations generally below 3000 ft except for the higher Lebanon Mountains; the lower ranges thus do not act as major barriers.

The terrain is relatively flat along the southern border of the eastern Mediterranean; the only significant topographical feature is Jabal Al Akhdar of eastern Libya.

In the Black Sea vicinity, there are major topographical barriers along the sea's southern and eastern boundaries. East of the Bosphorus, the Kuzey Anadolu Daglari of Turkey extends along the entire southern boundary and the Caucasus Mountains lie to the east. There is a break between these two mountain systems on the east coast of the Black Sea (Figure VII-1).

The major topographical feature of the western edge of the Black Sea is the Danube Basin. Because of the barrier created by the Carpathian Mountains, Transylvanian Alps and Balkan Mountains, there is no major opening for air flowing into the Black Sea from the west or southwest except the gap formed by the Dardenelles, Sea of Marmara and the Bosphorus.

---

*Comprises British forecast sea areas Bomba, Matruh, Delta, Taurus, Crusade, Danube, Georgia; see Figure 1b in the Introduction.

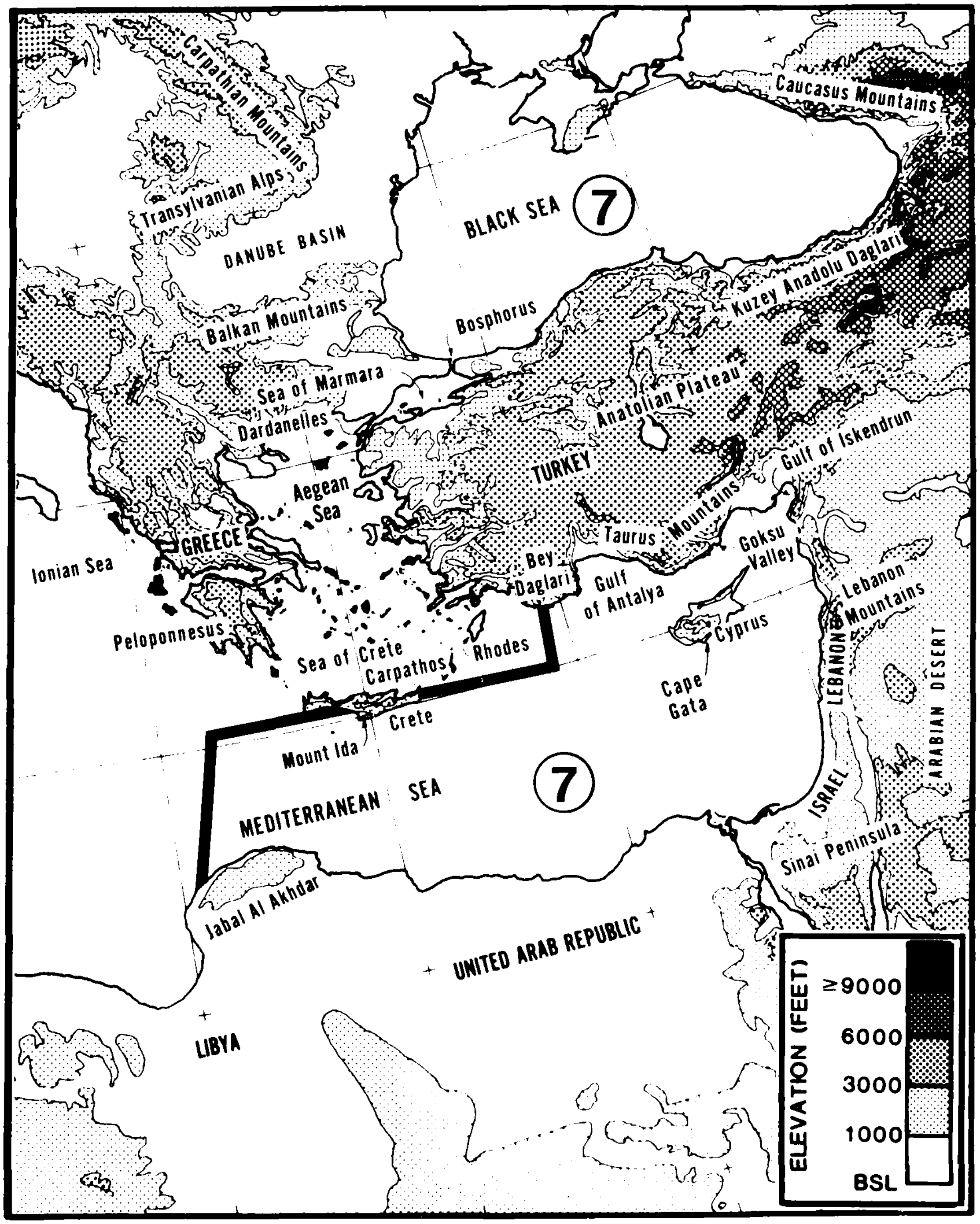


Figure VII-1. Topographical map of Eastern Mediterranean Area.

The northern boundary of the Black Sea is essentially flat with no major topographical barriers.

The topographical features found in the Eastern Mediterranean Area frequently combine to create channeling of the air flow, prominent corner effects, and/or obstacle effects to the large scale air flow caused by the various mountain barriers.

1.2 SEASONAL WEATHER

The seasonal weather patterns of the Eastern Mediterranean Area are controlled to a great degree by the monsoonal character of the surrounding land mass. During the winter season (November through February), the Eurasian land mass to the north is very cold in comparison to the sea surface temperature within the area. With the upper level westerlies often found over the Mediterranean, cyclonic activity with unsettled weather and strong winds is common.

During the summer season (June through September), the monsoonal effect leads to the development of an intense heat trough over southern Asia that extends westward over Turkey. With higher pressure over the relatively cooler sea surface of the Mediterranean, settled and dry weather with westerly winds persist during the summer.

The transitional seasons, spring and autumn, are of very different length. The relatively long spring season (March through May) is noted for periods of unsettled winter-type weather associated with increased occurrences of North African cyclones (see Para. 2.4); otherwise spring weather is much like summer's. Autumn usually lasts only one month (October), and is characterized by an abrupt change to the unsettled weather of winter.

2. REGIONAL WEATHER PHENOMENA

2.1 ETESIAN

The etesian is a northerly to westerly wind that occurs during the summer over the Aegean Sea and eastern Mediterranean Sea (see Para. 2.1 of Section VI).

In the Eastern Mediterranean Area, the etesian occurs as a southeastward extension of the wind regime from the Aegean Sea. The maximum winds axis passes southeastward through the opening between Rhodes and Crete, and then eastward with reduced strength to the south of Cyprus (see Figure VI-2 in Section VI). The direction of the etesian in the eastern Mediterranean follows the axis of maximum winds: northwesterlies east of Crete become westerlies south of Cyprus.

Gale force etesians are most likely in the sea area east of Crete, and occur with decreasing frequency southeastward; they can also occur along the south coast of Crete in the lee of coastal valleys. Although there is another axis of maximum etesian winds extending into the area from the Ionian Sea (see Figure VI-2 in Section VI), the probability of gale force winds along this axis is low.

Etesian weather over the eastern Mediterranean is generally dry with good visibilities. Because of the long overwater trajectory of the air, cumulus clouds are likely. Orographic wave clouds along the mountains of Crete also can be expected, especially during a gale force etesian.

2.2 BORA

The bora is a fall wind whose source is so cold that, when the air reaches the coast, the dynamic warming is insufficient to raise the air temperature to the normal level for the region (see Section IV, Para. 2.1). The bora is most common along the Yugoslavia coast, but it also occurs over the Aegean Sea; this latter occurrence occasionally extends into the eastern Mediterranean.

The extension of the bora from the Aegean into the eastern Mediterranean is associated with the cold outbreaks described in Section VI, Para. 2.3, and depends on the depth of the cold air. If the cold air is shallow (5,000 ft or less) over the Aegean Sea, bora conditions rarely extend south of Crete. If the cold air is deep (greater than 5,000 ft), the bora will cross Crete and move into the eastern Mediterranean. When the cold air crosses Crete, a ravine-type wind occurs at Timbakion on the south side of the island; northerly winds then occur at speeds two and a half times greater than those on the northern side of the island. The direction of the bora generally is northerly near Crete, becoming west-northwesterly in the eastern Mediterranean.

Weather associated with the bora in the eastern Mediterranean depends on the length of overwater trajectory of the cold, initially dry air. Since the cold air has a long overwater track and picks up moisture from the relatively warm water surface, convective cloudiness and some showers can be expected.

2.3 SIROCCO

The sirocco is a southeasterly to southwesterly wind over the Mediterranean originating over North Africa. Because the air's source regions are desert, the sirocco is extremely dry at its source, warm in winter, and hot in spring and summer. Its influence occasionally extends over the entire Mediterranean Basin, but it is most pronounced in the Gulf of Gabes east of the Atlas Mountains (see Section V, Para. 2.1).

In the eastern Mediterranean, the sirocco originates to the south over the deserts of Libya and the United Arab Republic and over the Arabian desert to the southeast. When the source is the Arabian desert, the direction of the sirocco is often southeasterly, especially along the coasts of Israel and Lebanon.

At some distance from the North African coast, the sirocco occurs most frequently during the cool season (November through April), where it is found east of the cyclones that develop either over the southern Aegean Sea/Cretan Sea or near Cyprus. Near the North African coast, the sirocco occurs most frequently during the spring (March through May) in association with the desert depressions that generally move eastward just south of the coast.

Weather associated with the sirocco is highly variable depending on the modifications that have occurred over the relatively cool water. Near the coasts of Libya, United Arab Republic, Israel and Lebanon, the air can be extremely dry with visibilities occasionally poor in blowing sand and/or dust. The dust clouds tend to be deep along the North African coast, but generally are shallow along the coast of Israel and Lebanon. Because of a strong surface inversion produced over the water, especially during the spring, extremely anomalous radar and radio propagation are likely.

By the time the sirocco reaches the coast of southern Turkey and Crete, the air has cooled and collected moisture in its lower layers; thus low stratus, fog and drizzle with low visibilities are common. Heavy rain is likely near frontal boundaries and along topographical barriers.

2.4 CYCLONE OCCURRENCES

Cyclonic activity affecting the eastern Mediterranean usually originates in the Southern Aegean Sea/Cretan Sea, in the Cyprus area just south of Turkish coast, or in North Africa (North African cyclones).

2.4.1 Southern Aegean Sea/Cretan Sea Cyclones

Cyclogenesis over the southern Aegean Sea/Cretan Sea is most likely to occur during the autumn and winter. These systems are often secondary developments of cyclones which originated either over the Ionian Sea or over the Gulf of Genoa before stalling off the west coast of Greece. A necessary, though not sufficient, requirement for rapid development is a vigorous invasion of cold air over the Aegean Sea as described in Section VI, Para. 2.3.

If a depression forms along the leading edge of the cold surge, it may move southward or even southwestward at first, but later it moves more predictably eastward to the Cyprus area (see Figure VII-2).

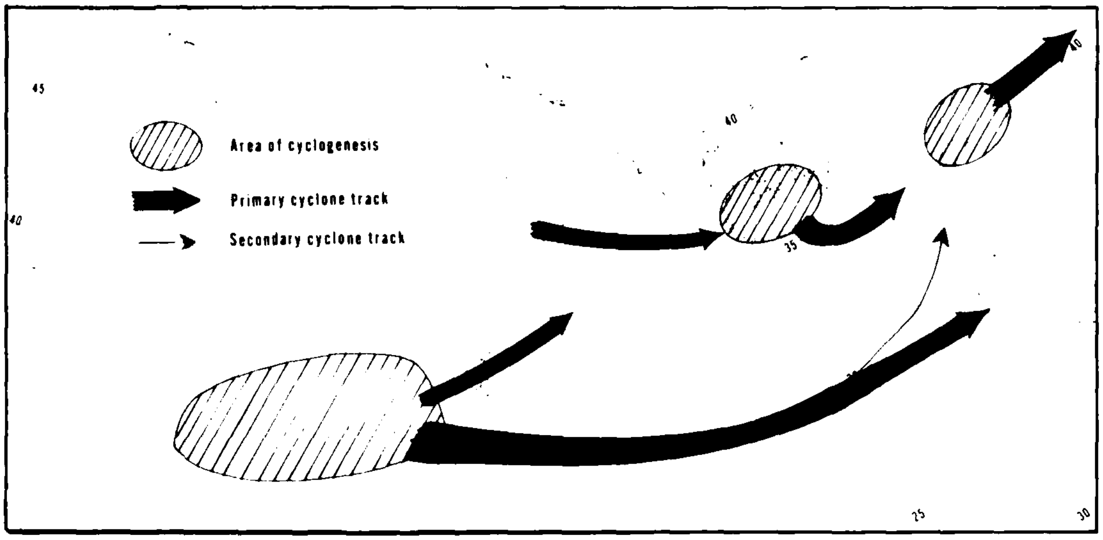


Figure VII-2. Areas of cyclogenesis and tracks of cyclones which affect the Eastern Mediterranean Area.

Sirocco conditions can be expected ahead of the cyclone if the trough of low pressure extends southward into North Africa. Heavy showers with poor visibilities are likely along and behind the associated cold front. Gale force winds greater than 33 kt are most likely north of the low center within the cold surge, but they also are likely to occur west of the depression.

2.4.2 Cyprus Depressions

The Cyprus depression develops in the lee of the Taurus Mountains of Turkey in the general region from the Gulf of Antalya to Cyprus (see Figure VIII-2). Although these cyclones can develop during any season, they usually become most intense from November through April.

Factors associated with the development of an intense Cyprus depression are probably similar to those associated with cyclogenesis in the Gulf of Genoa:

(1) The thermal contrast between land and water.

(2) Interaction between the polar front jet stream and the subtropical jet stream.

(3) Effect of northerly flow over the mountains of Turkey enhancing cyclogenetic activity along the southern slopes.

(4) Northern topographic features blocking of cold fronts' southward movement.

Weather conditions to the west of a Cyprus depression are typical for the case of cold air moving over relatively warm water, i.e., strong-to-gale-force, squally winds with heavy showers. Sirocco conditions may occur ahead of the developing low if desert air from the south or southeast is drawn into the circulation.

2.4.3 North African Cyclone

The North African cyclone (described in Section V, Para 2.5.1) develops over the desert region south of the Atlas Mountains. This system usually moves northeastward upon reaching the Tunisia/Gulf of Gabes region, but may continue moving eastward just south of the North African coast (see Figure VII-2). Since various tracks are possible, it can be very difficult to forecast when and if a North African cyclone will affect the eastern Mediterranean.

Of special concern to the forecaster in the eastern Mediterranean are the desert depressions that move eastward just south of the North African coast during the spring. These systems are hard to track because of the scarcity of timely surface data over North Africa. If the depressions deepen, they are likely to move northeastward.

If a North African cyclone moves out over the water, the sirocco becomes the primary weather phenomenon associated with it. In desert depressions that remain south of the North African coast, visibilities are reduced by dust clouds near the coast. Extremely anomalous radar and radio propagation are likely because of strong surface inversions.

3. FORECASTING RULES

Tables VII-1 through VII-4 provide quick reference to the 28 forecasting rules in this section. As indicated by the tables, the rules are numerically sequenced by type of occurrence and geographical location. Observing stations locations are shown in Figure VII-3 and listed in Table VII-5.

Table VII-1. Forecasting rules for wind regimes.

Etesian	General	Rule 1
	Local Variations	Rules 2-4
Sirocco		Rule 5
Cold Outbreaks		Rules 6, 7
Miscellaneous		Rules 8, 9

Table VII-2. Forecasting rules for cyclonic activity.

Cyclogenesis	General	Rule 10
	Cyprus area	Rules 11, 12
	North African area	Rule 13
Direction of Movement	General	Rule 14
	Cyprus area	Rule 15
	Crete area	Rule 16
	Black Sea area	Rule 17
Intensity	General	Rule 18
	Black Sea area	Rule 19

Table VII-3. Miscellaneous rules.

Frontal Activity		Rules 20, 21
Haze		Rules 22-24
Station Reports	Pressure	Rule 25
	Wind	Rule 26

Table VII-4. Forecasting rules for ports and anchorages.

Akrotiri Cyprus	Rule 27
Famagusta Cyprus	Rule 28

Table VII-5. List of observing stations.

Name of Station	Block No.	Index No.
Akrotiri	17	601
Famagusta	17	611
Rodus	16	749
Sitia	16	757
Souda Bay	16	746
Tobruk	62	062

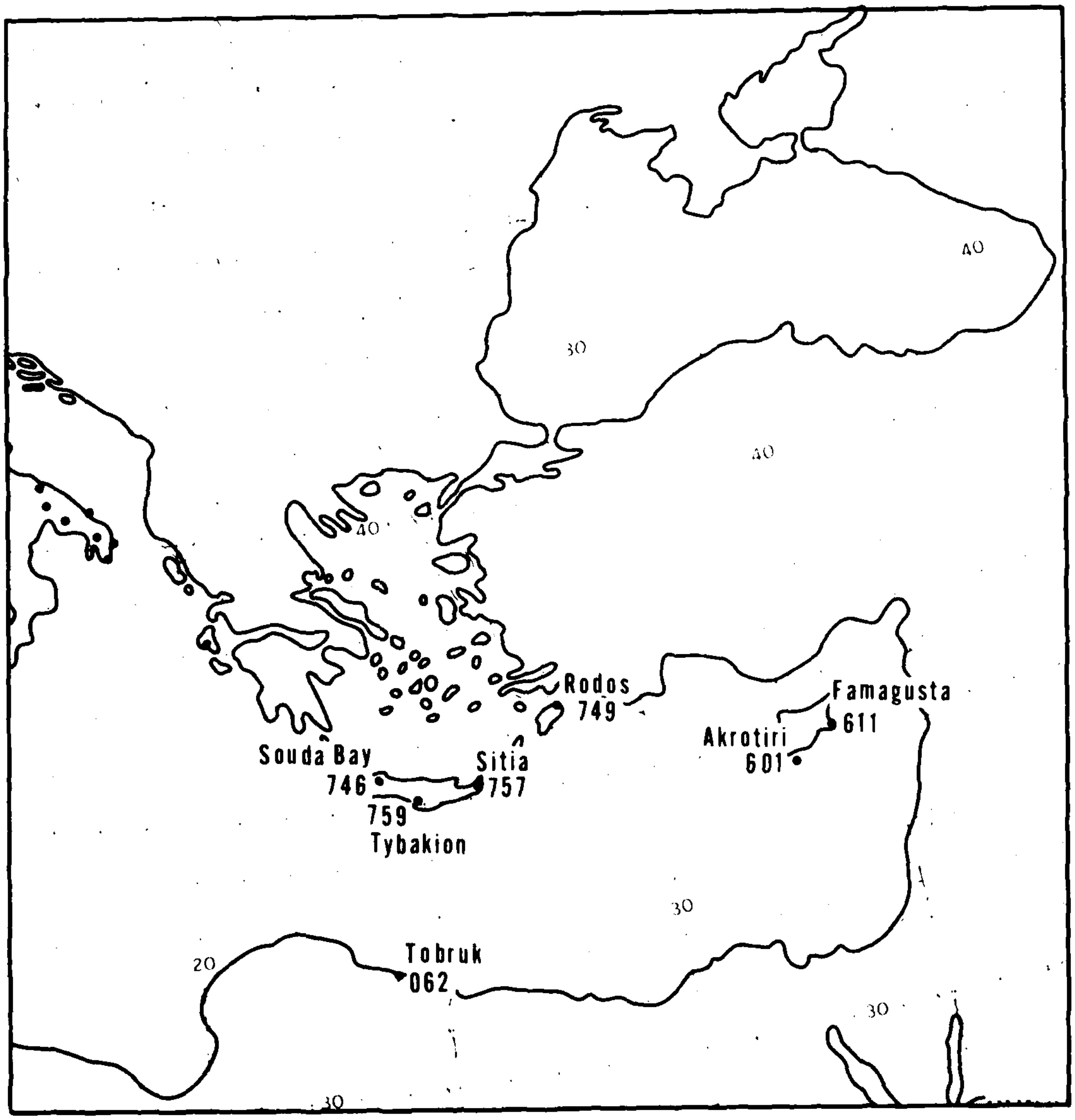


Figure VII-3. Station locator map for the Eastern Mediterranean Area.

WIND REGIMES, ETESIAN RULES 1-4

1. During a gale force etesian over the Aegean Sea, the axis of maximum winds passes southeastward through the opening between Rhodes and Crete into the eastern Mediterranean (see Figure VI-19 in Section VI). The strength of the etesian diminishes downward, and south of Cyprus its direction becomes westerly.

2. During an etesian, gale force winds extend into the area just east of Crete and south of Rhodes. Northerly winds 20-25 kt in the Aegean Sea increase to 25-32 kt with higher gusts off the coast of eastern Crete.

3. Etesian winds in the sea area east of Crete (see Figure VI-20 in Section VI) are 100% of the geostrophic speeds due to the channeling effect between Crete and the neighboring island of Carpathos. The direction of the flow is across the isobars at an angle of approximately 45° toward lower pressure difference between Rodus and Sitia.

4. Gale force winds are likely along the south coast of Crete during an etesian. Orographic wave clouds along the mountains of Crete are an indication of strong winds to the south.

WIND REGIMES, SIROCCO RULE 5

5. A good indication of the start of a sirocco in the eastern Mediterranean is the development of strong southerly winds at stations along the northeast coast of Libya.

WIND REGIMES, COLD OUTBREAKS; MISCELLANEOUS RULES 6-9

6. When a cold outbreak in the Aegean Sea extends southward across Crete, a ravine-type wind occurs at Tybakion on the south side of the island at the foot of Mount Ida. The speed of northerly winds at Tybakion may be twice or more as great as on the north side of the island.

7. Gale force northwesterlies occur in the eastern Mediterranean as an extension of the bora in the Aegean Sea if the cold air is deep (greater than 5,000 ft). Shallow cold air will not extend south of Crete and therefore will not affect the eastern Mediterranean.

8. There is a variant to the normal westerly flow south of Turkey during the summer season. If the north-south pressure gradient over Turkey, north of the thermal heat trough, is much stronger than normal, there will be occasional outbreaks of warm dry air occurring through gaps in the coastal mountains. During these outbreaks, the wind becomes north-northeasterly, the temperature rises, and the dew point falls abruptly. The outbreaks generally last between 20 minutes and one hour before the normal circulation is restored.

9. If summer winds are calm near Cyprus and stronger winds are sought for carrier operations:

(1) A day breeze can be found close inshore off Akrotiri even when winds are calm 15 n mi offshore.

(2) A night wind can be found about 40 n mi southwest of Cape Gata.

CYCLONIC ACTIVITY, CYCLOGENESIS RULES 10-13

10. Remnants of old cold fronts should be followed closely in the Mediterranean region. In several cases cyclogenesis has originated along one of these fronts, even after cloudiness associated with these fronts had disappeared. This phenomenon has occurred when an upper level shortwave trough (SD minimum) approached from the west.

11. Cyprus depressions usually form in the late autumn or early spring when a deep stream of cold air moves toward the eastern Mediterranean from the Balkans or the Black Sea.

12. Cyclogenesis can be expected to begin in the Cyprus area when a cold front approaches the Anatolian plateau from the north.

13. Strong surface ridging eastward across Morocco is an indication that a North African cyclone will move/develop over Tunisia, east of the Atlas Mountains. If surface winds at Algiers shift from southwesterly to northwesterly in association with the ridging, cyclogenesis will occur east of the Atlas Mountains.

CYCLONIC ACTIVITY, DIRECTION OF MOVEMENT RULES 14-17

14. During the spring, North African lows that have moved out over the Mediterranean will generally track toward the northeast if the heat trough over Turkey is deeper than 1000 mb. If a surface high or only a weak low is present over Turkey, however, North African lows can be expected to become stationary over the Ionian Sea in about 75% of the cases.

15. Cyclones developing on the southern edge of a cold surge over the Aegean Sea may move southward or even southwestward at first, but normally they later will move eastward to the Cyprus area.

16. Increasing southeasterly winds at Souda Bay are an indication that a North African cyclone is moving toward Crete.

17. A surface cyclone forecast to move northeastward across Turkey will normally stall at the southern coast. When this occurs, forecast a new center to develop over the Black Sea north of the mountain barrier.

CYCLONIC ACTIVITY, INTENSITY RULES 18, 19

18. The strongest winds associated with a deepening North African low, after the system moves out over the Mediterranean, occur in the northwest sector of the system rather than in the eastern sector.

19. An intense surface cyclone that crosses Turkey from the Mediterranean seldom produces gale force southerly winds over the Black Sea. Apparently, as the primary low moves across Turkey, a lee trough develops to the north over the Black Sea and causes the pressure gradient to weaken (see schematic in Figure VII-4). After the passage of the associated cold front, however, gale force westerly to northwesterly winds are likely.

MISCELLANEOUS RULES, FRONTAL ACTIVITY RULES 20, 21

20. Shallow cold fronts approaching the Mediterranean basin are greatly retarded by the mountain barriers. Deep cold fronts (those detectable at the 700 mb level) are not hindered by terrain features and at times even accelerate. The 400 mb level appears to be useful in forecasting this acceleration.

21. Cold fronts that move southward through the Aegean Sea usually stall on reaching the latitude of Crete. On the north side of the island, winds are northerly and weather poor with low clouds and drizzle. On the south side of the island, however, winds are southerly with clear skies and warm temperatures. The occurrence of the stationary front along the mountains of Crete can persist up to a week.

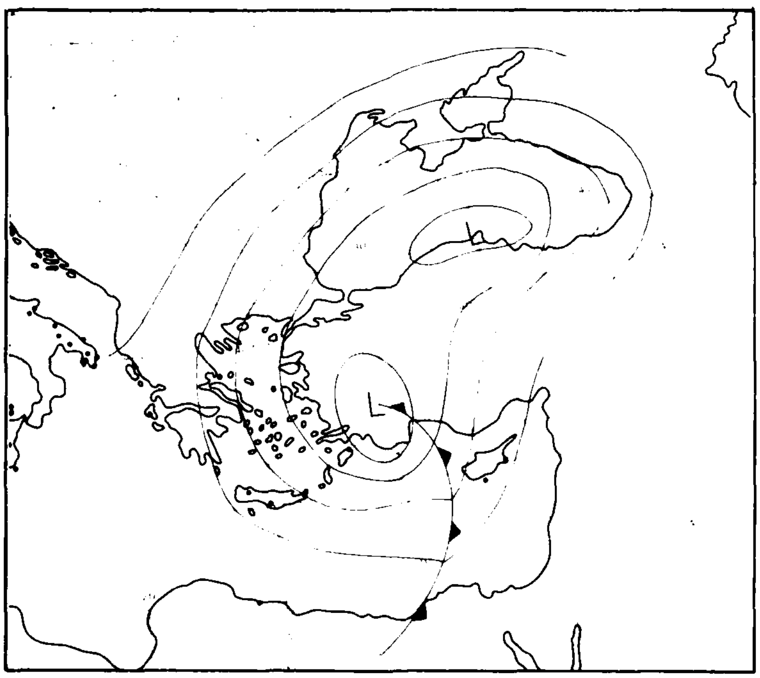


Figure VII-4. Schematic showing lee-trough development over the Black Sea in association with a primary low moving across Turkey.

MISCELLANEOUS RULES, HAZE RULES 22-24

22. Salt haze is a serious problem for flight operations over the Mediterranean. This haze has the following characteristics:

(1) It is most prevalent during the summer and early autumn.

(2) Its color is bluish white, as opposed to the brown of dust haze.

(3) Salt haze scatters and reflects light rays much more than does dust haze.

(4) Salt haze sometimes extends to over 12,000 ft and has been reported up to 20,000 ft.

(5) Although surface visibilities in salt haze may be as high as 4-6 n mi, the slant visibilities for a pilot making a landing approach may be near zero, especially if the approach is in the general direction of the sun.

(6) Salt haze is sometimes thicker aloft than at the surface.

(7) Salt haze is less of a problem after sunset since the poor visibility is caused partially by scattering and reflection.

23. Salt haze is most likely to develop in a stagnant air mass when there is a lack of mixing. This is especially prevalent when there is a strong ridge present at the surface and aloft.

24. Salt haze will not completely disperse until there is a change of air masses such as occurs with a frontal passage. Visibilities will improve, however, if there is an increase in the wind speeds at the 850 and/or 700 mb levels.

MISCELLANEOUS RULES, STATION REPORTS RULES 25, 26

25. The surface pressure reported at Tobruk appears to be too low.

26. Wind speeds at coastal stations in Israel and Cyprus are not good indicators of the wind strength at sea during periods of strong westerly flow in the eastern Mediterranean.

PORTS AND ANCHORAGES, AKROTIRI; FAMAGUSTA RULES 27, 28

27. The intensity of the sea breeze at Akrotiri has been reported to 35 kt during the summer. If the sky is clear with a west pressure gradient, and if the wind speed is at least 15-18 kt by 1030 LT, forecast the sea breeze to exceed 25 kt by 1700 LT.

28. The sea breeze at Famagusta, Cyprus, blows from the south or southwest. It is usually only moderate and does not require the issuance of wind warnings for small boating.

COMMANDER IN CHIEF
U.S. ATLANTIC FLEET
NORFOLK, VA 23511

COMMANDER IN CHIEF
U.S. PACIFIC FLEET
PEARL HARBOR, HI 96860

COMMANDER
SECOND FLEET
FPO NEW YORK 09501

COMMANDER
SIXTH FLEET
FPO NEW YORK 09501

COMMANDER
U.S. NAVAL FORCES, AZORES
APO NEW YORK 09406

COMMANDER
U.S. NAVAL FORCES, ICELAND
FPO NEW YORK 09571

COMMANDER
MIDDLE EAST FORCE
FPO NEW YORK 09501

COMMANDER NAVAL AIR FORCE
U.S. ATLANTIC LFEET
NORFOLK, VA 23511

COMMANDER NAVAL SURFACE FORCE
U.S. ATLANTIC FLEET
NORFOLK, VA 23511

COMMANDER
AMPHIBIOUS GROUP 2
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09501

COMMANDER OPERATIONAL TEST
AND EVALUATION FORCE
NAVAL BASE
NORFOLK, VA 23511

COMMANDER
SURFACE WARFARE DEVELOPMENT GROUP
NAVAL AMPHIBIOUS BASE, LITTLE CREEK
NORFOLK, VA 23521

COMMANDER
NAVAL SURFACE GROUP
MEDITERRANEAN
BOX 35
FPO NEW YORK 09521

COMMANDING OFFICER
USS AMERICA (CV-66)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09531

COMMANDING OFFICER
USS FORRESTAL (CV-59)
ATTN: METEOROLOGICAL OFFICER
FPO MIAMI 34080

COMMANDING OFFICER
USS INDEPENDENCE (CV-62)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09537

COMMANDING OFFICER
USS JOHN F. KENNEDY (CV-67)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09538

COMMANDING OFFICER
USS NIMITZ (CVN-68)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09542

COMMANDING OFFICER
USS DWIGHT D. EISENHOWER (CVN-69)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK [illegible]

COMMANDING OFFICER
USS SARATOGA (CV-60)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09587

COMMANDING OFFICER
USS CONSTELLATION (CV-64)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96635

COMMANDING OFFICER
USS CORAL SEA (CV-43)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96632

COMMANDING OFFICER
USS ENTERPRISE (CVN-65)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96636

COMMANDING OFFICER
USS KITTY HAWK (CV-63)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96634

COMMANDING OFFICER
USS MIDWAY (CV-41)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96631

COMMANDING OFFICER
USS RANGER (CV-61)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96633

COMMANDING OFFICER
USS MOUNT WHITNEY (LCC-20)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09517

COMMANDING OFFICER
USS BLUE RIDGE (LCC-19)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96628

COMMANDING OFFICER
USS GUADALCANAL (LPH-7)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09562

COMMANDING OFFICER
USS GUAM (LPH-9)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09563

COMMANDING OFFICER
USS INCHON (LPH-12)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09529

COMMANDING OFFICER
USS IWO JIMA (LPH-2)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09561

COMMANDING OFFICER
USS NEW ORLEANS (LPH-11)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96627

COMMANDING OFFICER
USS OKINAWA (LPH-3)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96625

COMMANDING OFFICER
USS TRIPOLI (LPH-10)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96626

COMMANDING OFFICER
USS TARAWA (LHA-1)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96622

COMMANDING OFFICER
USS PUGET SOUND (AD-38)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09544

COMMANDING OFFICER
USS LASALLE (AGF-3)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09577

COMMANDING OFFICER
USS LEXINGTON (AVT-16)
ATTN: METEOROLOGICAL OFFICER
FPO MIAMI 34088

COMMANDING OFFICER
USS NASSAU (LHA-4)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09557

COMMANDING OFFICER
USS SAIPAN (LHA-2)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09549

COMMANDING OFFICER
USS BELLEAU WOOD (LHA-3)
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96623

COMMANDER IN CHIEF ATLANTIC
NAVAL BASE
NORFOLK, VA 23511

SACLANT
ASW RESEARCH CENTER
APO NEW YORK 09019

SPECIAL ASSISTANT TO THE
ASSISTANT SECRETARY OF THE
NAVY (R&D)
ROOM 4E741
THE PENTAGON
WASHINGTON, DC 20350

CHIEF OF NAVAL RESEARCH
LIBRARY SERVICES (CODE 734)
RM 633, BALLSTON TOWER #1
800 QUINCY STREET
ARLINGTON, VA 22217

OFFICE OF NAVAL RESEARCH
CODE 100B
ATTN: DR. REED
ARLINGTON, VA 22217

OFFICE OF NAVAL RESEARCH
CODE 465
ARLINGTON, VA 22217

OFFICE OF NAVAL RESEARCH
CODE 462
ARLINGTON, VA 22217

CHIEF OF NAVAL OPERATIONS
(OP-952)
NAVY DEPARTMENT
WASHINGTON, DC 20350

CHIEF OF NAVAL MATERIAL (MAT-034)
NAVY DEPARTMENT
WASHINGTON, DC 22332

COMMANDANT OF THE MARINE CORPS
ASL-44
NAVY DEPARTMENT
WASHINGTON, DC 20380

DIRECTOR
ATTN: LIBRARY ACQUISITIONS,
2C029
NATIONAL SECURITY AGENCY
FT. MEADE, MD 20755

WEATHER ELEMENT
NATIONAL MILITARY COMMAND CENTER
THE PENTAGON - ROOM 2D921H
WASHINGTON, DC 20301

DEPUTY DIRECTOR FOR OPERATIONS
(ENVIRONMENTAL SERVICES)
OJCS, ROOM 1B679
THE PENTAGON
WASHINGTON, DC 20301

DET. 2, HQ, AWS
THE PENTAGON
WASHINGTON, DC 20330

NAVAL DEPUTY TO THE ADMINISTRATOR
NATIONAL OCEANIC & ATMOSPHERIC ADMIN.
ROOM 200, PAGE BLDG. #1
3300 WHITEHAVEN ST. NW
WASHINGTON, DC 20235

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL STATION
FPO SEATTLE 98791

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
BOX 63
U.S. NAVAL AIR STATION
FPO SAN FRANCISCO 96654

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
BOX 81
U.S. NAVAL AIR STATION
FPO SAN FRANCISCO 96637

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
FEDERAL BUILDING
ASHEVILLE, NC 28801

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
U.S. NAVAL AIR FACILITY
FPO SEATTLE 98767

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
BARBERS PT, HI 96862

CHIEF PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
CHASE FIELD
BEEVILLE, TX 78103

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
U.S. NAVAL AIR STATION
FPO NEW YORK 09560

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
BRUNSWICK, ME 04011

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
CARSWELL, AFB, TX 76127

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
CECIL FIELD, FL 32215

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL STATION
CHARLESTON, SC 29408

CHIEF PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR FACILITY
CHINA LAKE, CA 93557

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
CORPUS CHRISTI, TX 78419

CHIEF PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
DALLAS, TX 75211

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
FALLON, NV 89406

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
BOX 16
FPO NEW YORK 09593

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
BOX 9048
NAVAL AIR STATION
KEY WEST, FL 33040

CHIEF PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
KINGSVILLE, TX 78363

PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR ENGINEERING CENTER
LAKEHURST, NJ 08733

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
LEMOORE, CA 93245

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
BOX 72
FPO NEW YORK 09510

CHIEF PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
MAYPORT, FL 32228

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION, MEMPHIS
MILLINGTON, TN 38054

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
WHITING FIELD
MILTON, FL 32570

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
MERIDIAN, MS 39301

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
U.S. NAVAL AIR FACILITY, BOX 35
FPO SAN FRANCISCO 96614

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
APO SAN FRANCISCO 96519

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
MOFFETT FIELD, CA 94035

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
NAPLES, BOX 23
FPO NEW YORK 09520

CHIEF PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
NEW ORLEANS, LA 70146

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
WHIDBEY ISLAND
OAK HARBOR, WA 98277

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
AIR FORCE GLOBAL WEATHER CENTRAL
OFFUTT AFB, NE 68113

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
PATUXENT RIVER, MD 20670

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
U.S. NAVAL STATION
FPO MIAMI 34051

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
SAN DIEGO, CA 92145

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
U.S. NAVAL AIR FACILITY
FPO NEW YORK 09523

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
FPO NEW YORK 09528

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
SOUTH WEYMOUTH, MA 02190

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION, OCEANA
VIRGINIA BEACH, VA 23460

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
WILLOW GROVE, PA 19090

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
FPO SAN FRANCISCO 96685

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
FPO NEW YORK 09571

OFFICER IN CHARGE
U.S. NAVAL OCEANOGRAPHY COMMAND DET.
FLEET ACTIVITIES
FPO SEATTLE 98770

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
ALAMEDA, CA 94501

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
PENSACOLA, FL 32508

CHIEF PETTY OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL AIR STATION
GLENVIEW, IL 60026

OFFICER IN CHARGE
NAVAL OCEANOGRAPHY COMMAND DET.
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CA 93940

COMMANDING OFFICER
NAVAL RESEARCH LAB
ATTN: LIBRARY, CODE 2620
WASHINGTON, DC 20390

COMMANDING OFFICER
OFFICE OF NAVAL RESEARCH
EASTERN/CENTRAL REGIONAL OFFICE
BLDG 114 SECT. D
666 SUMMER ST.
BOSTON, MA 02210

COMMANDING OFFICER
NAVAL OCEAN RESEARCH & DEVELOPMENT ACTIVITY
CODE 101
NSTL STATION
BAY ST. LOUIS, MS 39529

COMMANDING OFFICER
FLEET INTELLIGENCE CENTER
EUROPE & ATLANTIC
NORFOLK, VA 23511

COMMANDER
NAVAL OCEANOGRAPHY COMMAND
NSTL STATION
BAY ST. LOUIS, MS 39529

COMMANDING OFFICER
NAVAL OCEANOGRAPHIC OFFICE, NAVY LIBRARY
NSTL STATION
BAY ST. LOUIS, MS 39522

COMMANDING OFFICER
FLEET NUMERICAL OCEANOGRAPHY CENTER
MONTEREY, CA 93940

COMMANDING OFFICER
NAVAL EASTERN OCEANOGRAPHY CENTER
MCADIE BLDG. (U-117)
NAVAL AIR STATION
NORFOLK, VA 23511

COMMANDING OFFICER
NAVAL POLAR OCEANOGRAPHY CENTER
NAVY DEPARTMENT
4301 SUITLAND ROAD
WASHINGTON, DC 20390

COMMANDING OFFICER
U.S. NAVAL OCEANOGRAPHY COMMAND CENTER
BOX 31
FPO NEW YORK 09540

COMMANDING OFFICER
OCEANOGRAPHY COMMAND FACILITY
P.O. BOX 85
NAVAL AIR STATION
JACKSONVILLE, FL 32212

COMMANDING OFFICER
NAVAL OCEANOGRAPHY COMMAND FACILITY
NAVAL AIR STATION, NORTH ISLAND
SAN DIEGO, CA 92135

COMMANDING OFFICER
U.S. NAVAL OCEANOGRAPHY COMMAND FACILITY
FPO SEATTLE 98762

SUPERINTENDENT
LIBRARY ACQUISITIONS
U.S. NAVAL ACADEMY
ANNAPOLIS, MD 21402

PRESIDENT
NAVAL WAR COLLEGE
NEWPORT, RI 02840

COMMANDER
NAVAL AIR SYSTEMS COMMAND HEADQUARTERS
ATTN: LIBRARY (AIR-00D4)
WASHINGTON, DC 20361

COMMANDER
NAVAL AIR SYSTEMS COMMAND HDQ (AIR-370)
WASHINGTON, DC 20361

COMMANDER
NAVAL AIR SYSTEMS COMMAND
METEOROLOGICAL SYSTEMS DIV. (AIR-553)
WASHINGTON, DC 20360

COMMANDER
NAVAL AIR SYSTEMS COMMAND (AIR-03)
WASHINGTON, DC 20361

COMMANDER
NAVAL OCEAN SYSTEMS CENTER
ATTN: CODE 4473
SAN DIEGO, CA 92152

COMMANDER
NAVAL AIR DEVELOPMENT CENTER (3011)
ATTN: N. MACMEEKIN
WARMINSTER, PA 18974

COMMANDER
EARTH & PLANETARY SCIENCES, CODE 3918
NAVAL WEAPONS CENTER
CHINA LAKE, CA 93555

DIRECTOR
NAVY SCIENCE ASSISTANCE PROGRAM
NAVSURFWEACEN, WHITE OAKS
SILVER SPRING, MD 20910

COMMANDER
PACIFIC MISSILE TEST CENTER
ATTN: GEOPHYSICS OFFICER (CODE 3250)
PT. MUGU, CA 93042

JAY ROSENTHAL
PACIFIC MISSILE TEST CENTER
PT. MUGU, CA 93042

CHIEF OF NAVAL EDUCATION & TRAINING
NAVAL AIR STATION
PENSACOLA, FL 32508

COMMANDING OFFICER
NAVAL AMPHIBIOUS SCHOOL
ATTN: AMPHIBIOUS WARFARE LIBRARY
NORFOLK, VA 23521

DEPARTMENT OF METEOROLOGY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CA 93940

DEPARTMENT OF OCEANOGRAPHY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CA 93940

LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CA 93940

WEATHER SERVICE OFFICER
OPERATIONS CODE 16
MARINE CORPS AIR STATION
BEAUFORT, SC 29902

COMMANDING OFFICER
MARINE CORPS AIR STATION
ATTN: WEATHER SERVICE OFFICE
CHERRY POINT, NC 28533

WEATHER SERVICE OFFICER
MARINE CORPS AIR FACILITY
QUANTICO, VA 22134

COMMANDING OFFICER
MARINE CORPS AIR STATION (HELICOPTER)
HQHQRON OPERATIONS DEPT.
ATTN: WEATHER SERVICE DIVISION
JACKSONVILLE, NC 28545

U.S. ATLANTIC FLEET (N009/04E)
NORFOLK, VA 23511

NAVAL SURFACE FORCE (N009)
U.S. ATLANTIC FLEET
NORFOLK, VA 23511

SUBMARINE FORCE
U.S. ATLANTIC FLEET
NORFOLK, VA 23511

ACOS TACTICAL DEV. & EVAL.
SECOND FLEET, BOX 100
CINCLANTFLT COMPOUND
NORFOLK, VA 23511

OPERATIONAL TEST & EVALUATION FORCE
U.S. NAVAL BASE
NORFOLK, VA 23511

NAVAL AIR FORCE
U.S. ATLANTIC FLEET (30F)
NAVAL AIR STATION
NORFOLK, VA 23511

COMMANDING GENERAL (G4)
FLEET MARINE FORCE, ATLANTIC
NORFOLK, VA 23511

MINE WARFARE COMMAND
U.S. NAVAL BASE (CODE 006)
CHARLESTON, SC 29408

COMFAIRMED
NSAP SCIENCE ADVISOR'S OFFICE
CODE 03A
FPO NEW YORK 09521

COMMANDER
AWS/DN
SCOTT AFB, IL 62225

USAFETAC/TS
SCOTT AFB, IL 62225

SUPERINTENDENT
ATTN: USAFA (DEG)
USAF ACADEMY, CO 80840

3350TH TECHNICAL
TRAINING GROUP
TTGU-W/STOP 623
CHANUTE AFB, IL 61868

AFGWC/DAPL
OFFUTT AFB,NNE 68113

3 WW/DN
OFFUTT AFB, NE 68113

AFGL/LY
HANSCOM AFB, MA 01731

5WW/DN
LANGLEY AFB, VA 23665

OFFICER IN CHARGE
SERVICE SCHOOL COMMAND, GREAT LAKES
DETACHMENT CHANUTE/STOP 62
CHANUTE AFB, IL 61868

HQ SAC/DOWA
OFFUTT AFB, NE 68113

HQ AFSC/WER
ANDREWS AFB, MD 20331

AFOSR/NC
BOLLING AFB, WASHINGTON DC 20312

COMMANDER
U.S. ARMY DEFENSE & READINESS COMMAND
ATTN: DRCLDC
5001 EISENHOWER AVENUE
ALEXANDRIA, VA 22304

COMMANDER & DIRECTOR
ATTN: DELAS-DM-A
U.S. ARMY ATMOS. SCIENCES LAB
WHITE SANDS MISSILE RANGE, NM 888002

COMMANDING OFFICER
U.S. ARMY RESEARCH OFFICE
ATTN: GEOPHYSICS DIV.
P.O. BOX 12211
RESEARCH TRIANGLE PARK, NC 27709

DIRECTOR
U.S. ARMY ENGINEERS WATERWAYS EXPERIMENT STATION
TECH. INFORMATION CENTER
ATTN: LIBRARY BRANCH
VICKSBURG, MS 39180

ENGINEER TOPOGRAPHIC LABS
ATTN: ETL-GS-A
FT. BELVOIR, VA 22060

DIRECTOR
DEFENSE TECHNICAL INFORMATION CENTER
CAMERON STATION
ALEXANDRIA, VA 22314

DIRECTOR OFFICE OF ENV. & LIFE SCIENCES
OFFICE OF THE UNDERSECRETARY OF DEFENSE FOR
RESEARCH AND ENGINEERING (E&LS)
ROOM 3D129
THE PENTAGON
WASHINGTON, DC 20301

CENTRAL INTELLIGENCE AGENCY
ATTN: OCR STANDARD DIST.
WASHINGTON, DC 20505

DIRECTOR
TECHNICAL INFORMATION
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BLVD
ARLINGTON, VA 22209

DR. R. W. JAMES
OPNAV 95201
U.S. NAVAL OBSERVATORY
34TH & MASSACHUSETTS AVE. N.W.
WASHINGTON, DC 20390

ACQUISITIONS SECTION IRDB-D823
LIBRARY & INFO. SERV. DIV. NOAA
6009 EXECUTIVE BLVD.
ROCKVILLE, MD 20852

FEDERAL COORDINATOR FOR METEOROLOGICAL
SERVICES & SUPPORTING RESEARCH
6010 EXECUTIVE BLVD
ROCKVILLE, MD 20852

NATIONAL WEATHER SERVICE
WORLD WEATHER BUILDING
ROOM 307
5200 AUTH ROAD
CAMP SPRINGS, MD 20023

NATIONAL CLIMATIC CENTER
ATTN: L. PRESTON, D542X2
FEDERAL BUILDING - LIBRARY
ASHEVILLE, NC 28801

DIRECTOR (OAx4)
INTERNATION AFFAIRS OFFICE, NOAA
6010 EXECUTIVE BLVD
ROCKVILLE, MD 20852

HEAD, ATMOSPHERIC SCIENCES DIV.
NATIONAL SCIENCE FOUNDATION
1800 G STREET, N.W.
WASHINGTON, DC 20550

DIRECTOR
DIVISION OF ATMOSPHERIC SCIENCES
NATIONAL SCIENCE FOUNDATION
ROOM 644
1800 G STREET, N.W.
WASHINGTON, DC 20550

EXECUTIVE SECRETARY
CAO SUBCOMMITTEE ON ATMOSPHERIC RESEARCH
NATIONAL SCIENCE FOUNDATION ROOM 510
1800 G STREET, N.W.
WASHINGTON, DC 20550

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
LIBRARY ACQUISITIONS
P.O. BOX 1470
BOULDER, CO 80302

DEPARTMENT OF ATMOSPHERIC SCIENCES
COLORADO STATE UNIVERSITY
ATTN: LIBRARIAN
FORT COLLINS, CO 80521

CHAIRMAN
DEPARTMENT OF METEOROLOGY
PENNSYLVANIA STATE UNIVERSITY
503 DEIKE BLDG
UNIVERSITY PARK, PA 16802

CHAIRMAN
DEPARTMENT OF METEOROLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MA 02139

ATMOSPHERIC SCIENCES DEPARTMENT
UNIVERSITY OF WASHINGTON
SEATTLE, WA 98195

DEPARTMENT OF METEOROLOGY
TEXAS A&M UNIVERSITY
COLLEGE STATION, TX 77843

DIRECTOR
OCEANOGRAPHIC INSTITUTE
OLD DOMINION UNIVERSITY
NORFOLK, VA 23508

HEAD
DEPARTMENT OF ENVIRONMENTAL SCIENCES
UNIVERSITY OF VIRGINIA, CLARK HALL
ATTN: R. PIELKE
CHARLOTTESVILLE, VA 22903

DEPT. OF ATMOSPHERIC SCIENCES LIBRARY
COLORADO STATE UNIVERSITY
FOOTHILLS CAMPUS
FORT COLLINS, CO 80523

ST. LOUIS UNIVERSITY
DEPT. OF EARTH & ATMOS. SCIENCES
P.O. BOX 8099 - LACLEDE STATION
ST. LOUIS, MO 63156

THE WALTER A. BOHAN CO.
2026 OAKTON STREET
PARK RIDGE, IL 60068

LIBRARY
THE RAND CORPORATION
1700 MAIN STREET
SANTA MONICA, CA 90406

MANAGER
METEOROLOGICAL SERVICES
PAN AMERICAN WORLD AIRWAYS, HANGAR 14
JFK INTERNATIONAL AIRPORT
JAMAICA, NY 11430

DIRECTOR OF METEOROLOGY
TRANS WORLD AIRLINES INC.
HANGAR 12 - ROOM 235
JFK INTERNATIONAL AIRPORT
JAMAICA, NY 11430

NAUTILUS PRESS, INC.
1056 NATIONAL PRESS BLDG.
WASHINGTON, DC 20045

THE EXECUTIVE DIRECTOR
AMERICAN METEOROLOGICAL SOCIETY
45 BEACON STREET
BOSTON, MA 02108

AMERICAN MET. SOCIETY
METEOROLOGICAL & GEOASTROPHYSICAL ABS.
P.O. BOX 1736
WASHINGTON, DC 20013

WORLD METEOROLOGICAL ORGANIZATION
ATS DIVISION (ATTN: N. SUZUKI)
CH-1211, GENEVA 20, SWITZERLAND

DIRECTOR OF NAVAL OCEANOGRAPHY & MET.
MINISTRY OF DEFENSE
OLD WAR OFFICE BLDG
LONDON, S.W.1. ENGLAND

METEOROLOGICAL OFFICE LIBRARY
LONDON ROAD
BRACKNELL, BERKSHIRE
RG 12 2SZ ENGLAND

MINISTRY OF DEFENCE
NAVY DEPARTMENT
ADMIRALTY RESEARCH LAB
TEDDINGTON, MIDDX
ENGLAND

DEPARTMENT OF METEOROLOGY
UNIVERSITY OF READING
2 EARLYGATE, WHITEKNIGHTS
READING RG6 2AU ENGLAND

EUROPEAN CENTRE FOR MEDIUM RANGE
WEATHER FORECASTS
SHINFIELD PARK, READING
BERKSHIRE RG29AX, ENGLAND

METEOROLOGIE NATIONALE
SMM/DOCUMENTATION
2, AVENUE RAPP
75340 PARIS CEDEX 07
FRANCE

SERVICE HYDROGRAPHIQUE ET OCEANOGRAPH.
DE LA MARINE
ESTABLISSEMENT PRINCIPAL
CENTRE DE DOCUMENTATION
RUE DU CHATELLIER, B.P. 426
29275 - BREST CEDEX
FRANCE

METEOROLOGIE NATIONALE
1 QUAI BRANLY
75, PARIS (7)
FRANCE

EUROPEAN SPACE AGENCY
METEOROLOGICAL PROGRAM DEPT.
TOULOUSE, FRANCE
ATTN: DR. J.P. ANTIKIDES

DIRECTION DE LA METEOROLOGIE MN/RE
ATTN: J. DETTWILLER
77 RUE DE SEVRES
92106 BOULOGNE-BILLANCOURT CEDEX
FRANCE

DIRECTOR
ISRAEL METEOROLOGICAL SERVICE
P.O. BOX 25
BET DAGEN 50200, ISRAEL

PROF. M. POREH
ISRAEL INSTITUTE OF TECHNOLOGY
TECHNICIAN CITY, HAIFA
ISRAEL 32000

DIRECTOR
RIVISTA DI METEOROLOGIA AERONATUICA
PALAZZO DELLA DIVILTA DEL LAVORO
QUADRATO DELLA CONCORDIA
7, 0144 ROMA
ITALY

DIRECTOR
ISTITUTO FISICA ATMOSFERA
PIAZZALE LUIGI STURZO 31
00144 - ROMA - EUR
ITALY

CONSIGLIO NAZIONALE DELLE RICERCHE
ISTITUTO TALASSOGRAFICO DI TRIESTE
VIALE R.GESSI 2 - 34123 TRIESTE
ITALY

DIRECTOR SACLANT ASW RESEARCH CENTRE
VIALE SAN BARTOLOMEU, 400
I-19026 LA SPEZIA, ITALY

ISTITUTO UNIVERSITARIO NAVALE
FOCOLTA DI SCIENZE NAUTICHE
ISTITUTO DI METEOROLOGIA E OCEANOGRAFIA
80133 NAPOLI - VIA AMM
ACTON, 38 ITALY

INSTITUTO HIDROGRAFICO
RUA DO ARSENAL-8
LISBOA 2, PORTUGAL

LABORATORIO OCEANOGREAFICO
PASEO DE LA FAROLA 27
MALAGA, SPAIN

INSTITUTO ESPANOL DE OCEANOGRAFIA
ALCALA 27, 4
MADRID (14), SPAIN

SPANISH OCEANOGRAPHY INSTITUTE
ALCALA 27
MADRIA 4, SPAIN

DIRECTOR GENERAL
TURKISH STATE METEOROLOGICAL SERVICE
P.O. BOX 401
ANKARA, TURKEY

SEYIR, HIDROGRAFI VE OSINOGRAFI
DAIRESI BASKANLIGI
ATTN: DIRECTOR
CUBUKLU-ISTANBUL
TURKEY

END
DATE
FILMED
9-81
DTIC